JOURNAL STAFF

EDITOR: Naomi F. Miller, University of Pennsylvania Museum–MASCA, 33rd and Spruce Sts., Philadelphia, PA 19104 (nmiller0@sas.upenn.edu)

BOOK REVIEW EDITOR: Darron Collins, Latin American and Caribbean Secretariat, World Wildlife Fund, 1250 24th St., NW, Washington, DC 20037-1193 (darron.collins@wwfus.org)

SOCIETY OFFICERS

PRESIDENT: Karen R. Adams, Crow Canyon Archaeological Center, Cortez, CO

PRESIDENT-ELECT: Jan Timbrook, Santa Barbara Museum of Natural History, Santa Barbara, CA

SECRETARY/TREASURER: C. Margaret Scarry, Department of Anthropology, University of North Carolina, Chapel Hill, NC (scarry@email.unc.edu)

BOARD OF TRUSTEES

M. Kat Anderson, University of California, Davis, CA

Leslie Main Johnson, University of Alberta, Edmonton, Alberta, Canada

John D. Speth, University of Michigan, Ann Arbor, MI

SOCIETY COORDINATORS

CONFERENCE COORDINATOR: Mollie S. Toll, Museum of New Mexico, Office of Archaeological Studies, Box 2087, Santa Fe, NM 87504

WEBSITE COORDINATOR: Douglas Trainor (trainor@ethnobiology.org)

Ex Officio

Past presidents: **Steven A. Weber, Amadeo M. Rea, Elizabeth S. Wing, Paul E. Minnis, Cecil Brown, Catherine S. Fowler, Nancy J. Turner, and Deborah M. Pearsall**

Permanent board member **Steven D. Emslie**

Editor, conference coordinator, and website co-ordinator

EDITORIAL BOARD

Eugene N. Anderson, University of California, Riverside, CA: *ethnobotany, China, Maya*

Scott Atran, CNRS, Paris, France: *ethnobiological classification, ethnoecology, cognition, evolutionary psychology, history of science, Maya, Middle East*

William Balée, Tulane University, New Orleans, LA: *historical ecology, ethnobotany, Amazonia*

Brent Berlin, University of Georgia, Athens, GA: *ethnobiological classification, medical ethnobotany, Maya*

Robert A. Bye, Jr., Jardín Botanico, Universidad Nacional Autónoma de México, México, D.F.: *ethnobotany, Mexico*

George Estabrook, University of Michigan, Ann Arbor, MI: *Mediterranean peasant agriculture, Portuguese speaking world, culturally informed technology, computational methods*

Nina Etkin, University of Hawaii, Honolulu, HI: *medical ethnobotany, ethnopharmacology, ethnobiology of food, West Africa, Pacific*

Gayle Fritz, Washington University, St. Louis, MO: *paleoethnobotany, agricultural origins and developments, North America*

Chris Healey, Centre for Indigenous Natural and Cultural Resource Management, Northern Territory University, Darwin, Australia: *ethnobiological classification, ethnoecology, Melanesia, Indonesia, Australia*

Brian Hesse, University of Alabama at Birmingham, Birmingham, AL: *zooarchaeology, animal domestication, pastoral systems, Near East, Andes*

Eugene Hunn, University of Washington, Seattle, WA: *ethnobiological classification, ethnoecology, Sahaptin and Zapotec languages, subsistence use of parks*

Timothy Johns, Macdonald College of McGill University, Montreal, Quebec: *Africa and the Americas, ethnobotany, medicinal plants, nutrition*

Harriet V. Kuhnlein, McGill University, Quebec, Canada: *Ethno/human nutrition; nutrition of Indigenous Peoples*

David L. Lentz, Chicago Botanic Garden, Glencoe, IL: *paleoethnobotany, Mesoamerica, North America, Central Asia*

Brien Meilleur, CNRS, Paris, France: *ethnoecology, traditional knowledge and plant conservation, Alpine Europe, Polynesia*

Elizabeth Reitz, University of Georgia, Athens: *zooarchaeology*

Editorial consultant: **Elia San Miguel** (Spanish), Real Jardín Botánico de Madrid, Spain

The *Journal of Ethnobiology* is published semi-annually by the Society of Ethnobiology (www.ethnobiology.org). Manuscripts for publication and book reviews should be sent to the appropriate editors as listed in the inside back cover of this issue.

© Society of Ethnobiology

ISSN 0278-0771

COVER ILLUSTRATION: Yakama man picking huckleberries (Mack and McClure, this issue, Figure 2).

MISSOURI BOTANICAL

AUG 2 0 2002

GARDEN LIBRARY

Journal of Ethnobiology

VOLUME 22, NUMBER 1 SUMMER 2002

CONTENTS

ETHNOBIOTICA v

OBSERVATIONAL STUDY OF MAIZE PRODUCTION SYSTEMS OF ZUNI FARMERS IN SEMIARID NEW MEXICO
Deborah A. Muenchrath, Maya Kuratomi, Jonathan A. Sandor, and Jeffrey A. Homburg 1

***VACCINIUM* PROCESSING IN THE WASHINGTON CASCADES**
Cheryl A. Mack and Richard H. McClure 35

UNDERDIFFERENTIATED TAXA AND SUBLEXICAL CATEGORIZATION: AN EXAMPLE FROM MATSES CLASSIFICATION OF BATS
David W. Fleck, Robert S. Voss, and Nancy B. Simmons 61

COMPARATIVE ETHNOMYCOLOGICAL SURVEY OF THREE LOCALITIES FROM LA MALINCHE VOLCANO, MEXICO
A. Montoya, A. Estrada-Torres, and J. Caballero 103

'ORPHAN TREES OF THE FOREST': WHY DO NTUMU FARMERS OF SOUTHERN CAMEROON PROTECT TREES IN THEIR SWIDDEN FIELDS?
Stéphanie M. Carrière 133

BOOK REVIEWS 163

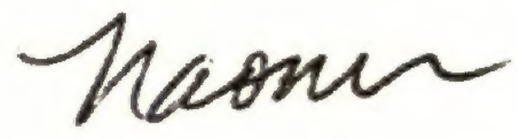
GUIDELINES FOR AUTHORS 173

ETHNOBIOTICA

By the time you read this, I will be working away on my second issue as editor of the *Journal of Ethnobiology*. So now is the best time to thank Bill Balée for having put out the *Journal* for the past three years, and for his words-to-the-wise and ongoing consultations. I would also like to introduce you to our new book review editor, Darron Collins. Darron, an ethnobotanist and ecologist, does fieldwork in Mesoamerica. He recently received his doctorate from Tulane University under the supervision of Bill Balée, and he currently works for the World Wildlife Fund as forest conservation coordinator for Latin America and the Caribbean. Do let him know if you are interested in reviewing books for the *Journal* (see inside back cover for details).

As for me, I would like to think my training in the four-field tradition of anthropology is good preparation for editing our interdisciplinary journal. For those who do not yet know me, I am an archaeologist with a geographical interest in the Near East (southwest Asia) and a topical interest in (paleo)ethnobotany. The great antiquity of agriculture in southwest Asia led me to my major research interest: the long-term human impact on the environment. Given the nature of Near Eastern agriculture—wheat, barley, pulses, sheep, goat, cattle (and pig in some times and places)—it is not difficult to connect botanical and faunal studies through my favorite substance, seed-filled animal dung.

You will see some minor format changes in this issue, which also contains revised guidelines for authors (p. 173). We have not changed the *Journal*'s mission to publish original research on all aspects of the relationship between people and the rest of the living world, past and present. As no one can be an expert in all aspects of an interdisciplinary subject such as ours, and as a way of encouraging collaboration among colleagues, I would like to take this opportunity to invite you to submit articles that cut across two or more dimensions of the our field—plants and animals, ancient and modern, Old World and New World, to name a few.



Journal of Ethnobiology 22(1): 1–33 Summer 2002

OBSERVATIONAL STUDY OF MAIZE PRODUCTION SYSTEMS OF ZUNI FARMERS IN SEMIARID NEW MEXICO

DEBORAH A. MUENCHRATH,[a] MAYA KURATOMI,[b]
JONATHAN A. SANDOR,[a] and JEFFREY A. HOMBURG[c]

[a]*Agronomy Dept.—Crop, Soil, and Environmental Sciences, Iowa State University, Ames, IA 50011-1010*

[b]*Soil Science Dept., 1991 Upper Buford Circle, University of Minnesota, St. Paul, MN 55108*

[c]*Statistical Research, Inc., 6099 E. Speedway Blvd., P.O. Box 31865, Tucson, AZ 85751-1865*

ABSTRACT.—For more than 2,000 years, the Zuni and their ancestors have cultivated maize in semiarid New Mexico, relying on natural landscape processes to channel water and nutrients to their crops. Runoff generated by localized thunderstorms spreads across fields located on alluvial fans. This study documents soil properties, production practices, and maize yields of four traditional runoff fields of Zuni farmers. All fields received at least two runoff events that deposited sediments and organic debris during the season. Fields exhibited adequate macronutrients for low-density crop production and textural sorting of sediments. Management level is largely determined by time, labor, equipment, and transportation availability. Farmers commonly plant during May, sowing multiple maize seeds together at a depth of about 15 cm in widely-spaced clusters. Each field contained two or more open-pollinated maize folk cultivars, sometimes interspersed with other crops. Maize population densities varied widely, averaging 9650 plants/ha (SE ± 1281). Mean grain yield was 572 (± 181) kg/ha. Greatest yield, 1841 kg/ha, was obtained from the field having moderate maize density, few weeds, and planted in mid-May. Delayed planting and weeds suppressed yields in the other fields. Yield potential of these systems, however, is likely greater than observed. Geographic and geomorphic diversity of fields reduces risks.

Key words: indigenous agricultural knowledge, Native American agriculture, runoff agriculture, maize, soil.

RESUMEN.—Durante más de 2000 años, los Zuni y sus ancestros han cultivado maíz en el Nuevo Mexico semiárido, y han manejado cuencas con la finalidad de canalizar el agua y los nutrientes hacia sus cultivos. El escurrimiento superficial generado por las tormentas locales se distribuye a través de los campos ubicados sobre abanicos aluviales. Este estudio documenta las propiedades del suelo, las prácticas productivas, y los rendimientos de maíz en cuatro campos tradicionales de escurrimiento manejados por los agricultores Zuni. Todos los campos presentaron al menos dos fenómenos de escurrimiento durante la estación, los cuales depositaron sedimentos y detritus orgánico. Los campos mostraron macronutrientes adecuados para una producción de cosechas de baja densidad de siembra y un repartimiento de varias clases sedimentarias. La intensidad de manejo la determina principlamente la disponibilidad de tiempo, mano de obra, equipamiento y transporte. La siembra se produce comúnmente en mayo. Los agricultores siem-

bran maíz a una profundidad de unos 15 cm en montículos de múltiples plantas. Cada campo contiene dos o más cultivares tradicionales de maíz de polinización abierta, a veces mezclados entre otros cultivos. Las densidades de población de maíz varían ampliamente en torno a una media de 9650 plantas/ha (SE ± 1281). La producción media de grano fue 572 (± 181) kg/ha. La producción mayor, 1841 kg/ha, se obtuvo en un campo con una densidad poblacional moderada, pocas malezas, y con fecha de siembra de mediados de mayo. El retraso en la siembra y las malezas redujeron la producción en los otros campos. Es posible que el nivel de producción de estos sistemas sea mayor de lo observado. La diversidad geográfica y geomorfológica de los campos reduce los riesgos.

RÉSUMÉ.—Pendant plus de 2000 ans, les Zuni et leurs ancêtres ont cultivé le maïs dans le New Mexico semi-aride, comptants sur des processus du paysage naturel pour canaliser l'eau et les substances nutritives vers leurs cultures. L'eau de ruissellement provenant d'averses locales s'étend sur les champs situés sur des petits deltas alluviaux. Cette étude documente les caractères des sols, les pratiques de production, et le rendement du maïs sur quatre champs appartenants à des agriculteurs Zuni et traditionnellement approvisionés par des ruissellements. Pendant la belle saison, chaque champ a reçu au moins deux épisodes de ruissellement qui déposaient sédiments et débris organiques. Les champs contenaient des micronutriments adéquats pour la culture à basse densité et un triage textural des sédiments. Le niveau des interventions est determiné par la disponibilité de temps, de main-d'œuvre, d'équipement et de transport. En général, les agriculteurs sèment pendant le mois de mai, avec le maïs planté à une profondeur d'à peu près 15 cm en groupes de multiples plantes. Chaque champ contient au moins deux variétés traditionnelles à pollinisation ouverte, parfois intercalées aux autres cultures. La densité des populations du maïs, qui variait considérablement d'un champ à l'autre, était en moyenne de 9650 plantes/ha (déviation d'erreur ± 1281). Le rendement moyen était de 572 (± 181) kg/ha. Le plus haut rendement, de 1841 kg/ha fut réalisé dans un champ avec peu de mauvaises herbes, de densité moyenne, et semé à mi-mai. Une ensemencement tardif et les mauvaises herbes réduisaient le rendement dans les autres champs. Le rendement potentiel de ces systèmes est vraisemblablement plus élevé que nous l'avons observé. La géographie et la géomorphologie diversifiées des champs réduisent les risques.

INTRODUCTION

Worldwide, water is the single most limiting resource for crop production. Increasing demand for water by agricultural and non-agricultural users, environmental deterioration, and the threat of global climate change challenge the long-term sustainability of agriculture and socio-economic development in the arid and semiarid western United States and other drought-susceptible regions of the world (e.g., FAO 2000; Gleick 2000; OTA 1983). Arid and semiarid zones occupy more than a third of the Earth's land surface, with dry regions located in nearly half of the world's nations. Over 80 percent of the world's cultivated land is rainfed, relying solely on precipitation and runoff; these lands produce more than 60 percent of the global food supply (FAO 2000).

Rain could be better utilized to support agricultural productivity through management of storm-runoff water (Anaya 1992; Bruins et al. 1986; Critchley and Siegert 1991; FAO 2000; OTA 1983). Rainwater-harvesting methods have been suc-

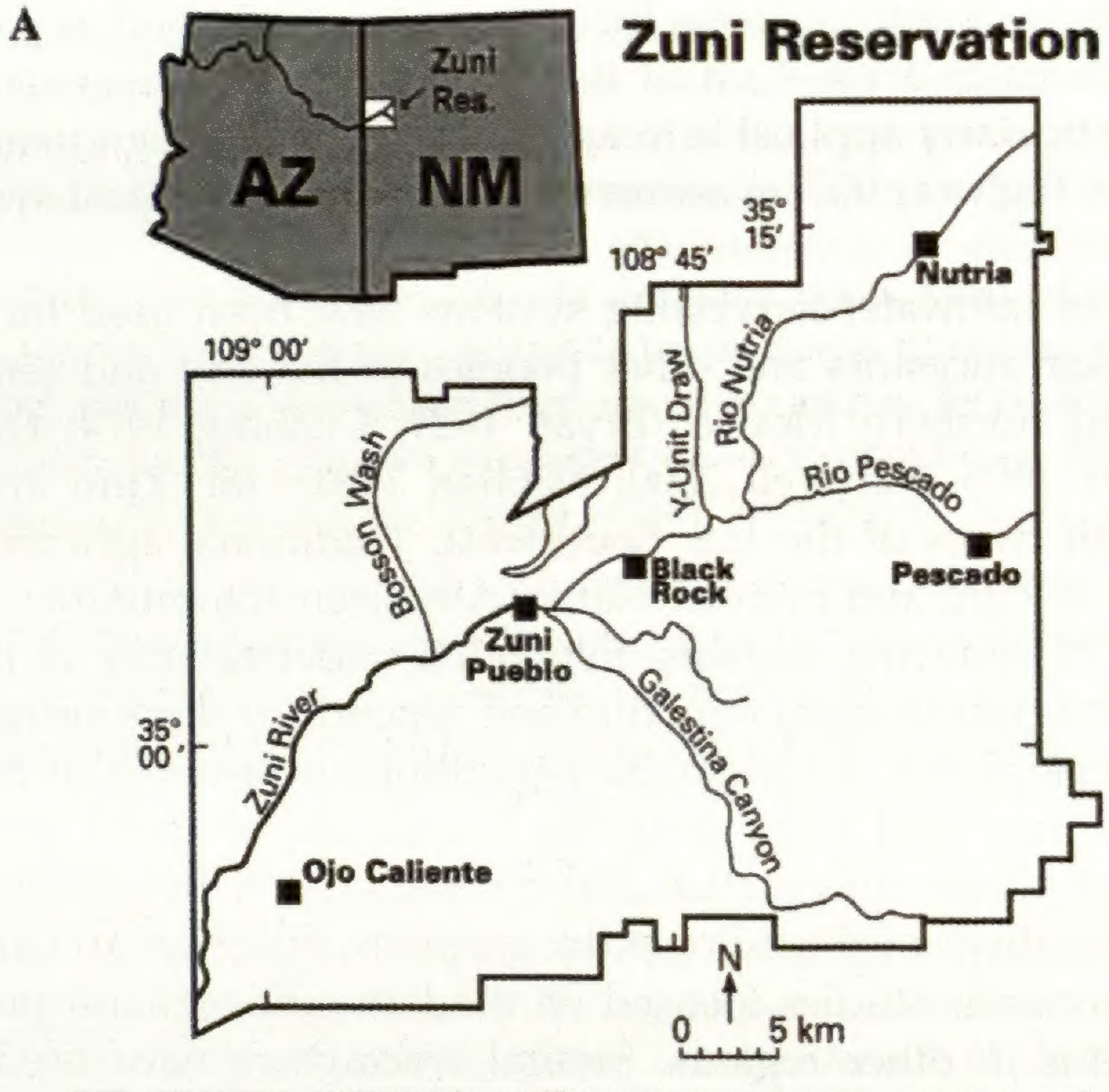
cessfully used in traditional systems throughout the world and as part of modern agricultural systems in areas such as the Negev Desert. These water-harvesting methods are particularly applicable to agricultural development in arid and semiarid areas where high capital investment or highly technological systems are environmentally, socially, or economically unsuitable.

A diversity of rainwater-harvesting systems have been used for centuries by the Zuni and their ancestors and other peoples in the arid and semiarid southwestern U.S. and northern Mexico (Bryan 1929; Cushing 1974; Doolittle 2000; Hack 1942; Hart 1995; Maxwell 2000; Nabhan 1984); the Zuni are one of the western Puebloan tribes of the U.S. Southwest. Traditional agricultural systems presently found at Zuni and in other Native American communities in the region provide models of enduring systems. Expanded understanding of their adapted cultivars and the agroecological structure and function of these systems may contribute to the development of sustainable agricultural systems to successfully meet the challenges of increased water demands in arid and semiarid areas.

Most of the available information about traditional Native American agriculture in the U.S. Southwest is based on ethnographies, historical and archaeological records, and agronomic studies focused on modern cultivars and practices or on traditional systems in other regions. Several researchers have used such information to model productivity of ancient and current traditional systems (e.g., Rhode 1995; Van West 1996). Little research, however, has been conducted on specific agronomic characteristics of traditional cultivars and associated practices. Documentation of these time-tested systems is urgent. Traditional agricultural knowledge in the Southwest is rapidly eroding as fewer indigenous farmers apply that knowledge or pass it on to younger generations (Brandt 1995). Commercial production of alfalfa, increasingly important on reservations, also threatens to further displace traditional techniques.

The observational study reported here documents contemporary runoff agricultural practices of several Zuni farmers and explores general relationships among soil properties, production practices, and maize productivity of their fields. This study is part of a larger research project designed to examine the agroecological structure and function of traditional runoff agriculture in this semiarid environment (e.g., Sandor et al. 1999).

Location and Landscape.—The Zuni Indian Reservation is located in the mesa country of western New Mexico in the southeastern part of the Colorado Plateau (Figure 1). Topography is controlled by mainly flat-lying to gently dipping strata of uplifted sedimentary rocks with variable resistance to erosion. Alternating strata of resistant sandstone and more erodible shale of mostly Triassic to Cretaceous age underlie mesas and cuestas (Orr 1987). Mesas are separated by narrow canyons to broad alluvial valleys. Valley margins, where traditional runoff agriculture is usually practiced, mostly comprise areas of coalescing alluvial fans where ephemeral streams deposit mixed sediments from mesa uplands. Soils grade from Alfisols (soils having subsurface clay accumulation) and Aridisols (desert soils with subsurface development) in the drier western portion to Mollisols (soils having thick topsoil rich in organic matter) and Alfisols in the higher eastern valleys of the reservation (Soil Survey Staff 1999; USDA-NRCS, publication pending).



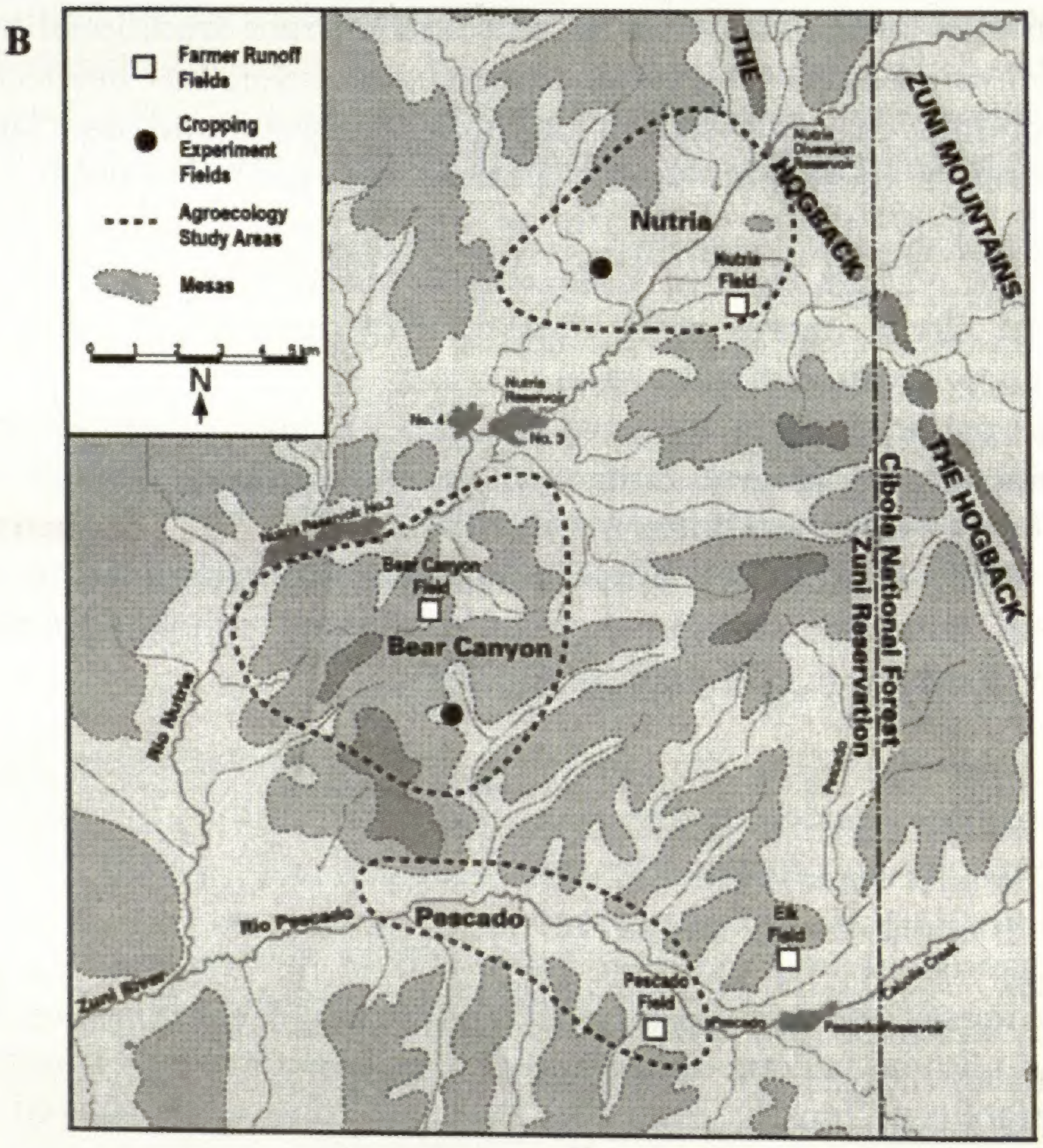


FIGURE 1.—Maps showing the locations of the a) Zuni Reservation, and b) farmer runoff fields included in the study.

From lower to higher areas, soil temperature regime varies from thermic to mesic, and soil moisture regime from aridic to ustic (semiarid). Elevation ranges from 1838 m near the Arizona border to 2347 m on eastern mesas, near the continental divide.

Climate.—Precipitation and temperature at Zuni are largely functions of elevation and landforms, with high spatial and temporal variability. Annual precipitation at Blackrock, in the central part of the reservation at an elevation of 1967 m, averages about 300 mm, but varies widely from year to year (coefficient of variation, 23%) (Balling and Wells 1990; Ferguson and Hart 1985; Kintigh 1985; Tuan et al. 1973). Precipitation generally increases with increasing elevation. Approximately half of the annual precipitation occurs during the summer monsoon season, usually extending from July through September. Summer rains ordinarily occur as highly localized, brief, intense thunderstorms. Traditional runoff agriculture depends on these monsoon rains. The remainder of the precipitation is usually received as lower intensity rain or snow from November through March. May and June are the driest months; June has a long-term average of only 10 mm. Zuni spring and early summer seasons are dry and windy.

The frost-free period, when temperatures exceed 0°C, extends on average from May 16 through October 12, averaging 150 days (s.d. 21 days) at Blackrock (Kintigh 1985; Tuan et al. 1973). The frost-free period is generally shorter at higher elevations. Although temperatures may stay above freezing, spring and early summer night temperatures are often well below the 8 to 10°C minimum required for maize growth (Brandt 1995; Shaw 1988). Local temperature is influenced by wind and terrain, including elevation, aspect, and slope.

The semiarid climate of Zuni supports native vegetation dominated by juniper (*Juniperus* spp.), pinyon (*Pinus edulis*), and Gambel oak (*Quercus gambelii*) woodlands on mesa uplands. Valleys are semiarid grasslands dominated by big sagebrush (*Artemisia tridentata*) and blue grama (*Bouteloua gracilis*).

Zuni Agriculture.—Direct rain alone is insufficient to fully support crop production in most years (Kintigh 1985). Growing season moisture deficit (atmospheric evaporative demand less available soil-stored moisture and precipitation) averages 349 mm (Rhode 1995; Tuan et al. 1973). Zuni farmers report moisture and temperature as their major concerns for crop production (Brandt 1995). Over the centuries, Zuni developed an agricultural system that capitalizes on natural landscape processes to increase water and nutrient availability for crop production and to provide some protection from frost.

Most traditional fields are located where floodwaters occasionally flow. Fields are situated on valley margin alluvial fans and mesa footslopes. These landscape positions permit cold-air drainage away from crops and capture storm floodwaters to augment water availability. Ephemeral storm water, conducted by channel and overland flow from watersheds upslope, is diverted to fields and managed using earthen berms or bunds, stone and/or wooden dams, and shallow ditches (Cushing 1974; Ferguson and Hart 1985; Kintigh 1985). Farmers credit such flows, together with the organic-rich materials transported by runoff water, with supplying moisture and nutrients to support crop production (Norton et al. 1998). Neither synthetic fertilizers nor manure are applied to runoff fields. Crop pro-

ductivity of these fields reflects integrated watershed and crop processes and management.

Although spring winds are particularly drying and can desiccate seedlings, field sites are not specifically selected to provide wind protection. Traditionally, planting was done on the leeward side of the previous year's crop stubble (Cushing 1974:181); the stubble may have provided some wind protection to the emerging seedlings.

Maize (*Zea mays* L.) is the staple crop produced by Zuni farmers using runoff agricultural practices. Local cultivars of open-pollinated maize are sometimes intercropped with beans (*Phaseolus* spp.) and squash (*Cucurbita* spp.), and rotated with fallow periods (Bohrer 1960; Brandt 1995; Manolescu 1994). Maize has long been central to Zuni social, spiritual, and ceremonial life (Cushing 1974; Ferguson and Hart 1985; Kintigh 1985).

Ancient and Historical Contexts.—Zuni agriculture was extensive and well established by 2000 years ago (Damp et al. 2002). Maize radiocarbon dated to about 2200 B.P. has been found at Zuni (Rhode 1990). Prehistoric ceramics associated within field houses indicate that many Zuni runoff fields are at least 1000 years old (Homburg 2000). The archaeological record documents a long-term occupation of the Zuni area, one that is unusually continuous for the Southwest, with increasing reliance on agriculture through time (Damp et al. 2002; Ferguson 1996; Kintigh 1985; Rhode 1990).

Historic records attest to the skill of Zuni as desert agriculturalists. Coronado, who conquered Zuni in A.D. 1540, described Zuni as having great stores of maize (Hammond and Rey 1940). High agricultural productivity at Zuni was also noted in mid-nineteenth century reports of the U.S. military in the region, which depended on the Zuni for maize and other food supplies (Hart 1995). Over 4000 ha were reported in production at Zuni, mostly in rainfed-runoff agriculture, with some fields located nearly 100 km from the Pueblo of Zuni (Ferguson and Hart 1985; Sitgreaves 1853).

Through the early 1900s, most Zuni fields were situated on valley margins to take advantage of storm runoff floodwaters (Brandt 1995; Hart 1995). Zuni also farmed on floodplains around the Pueblo of Zuni and near the farming villages of Nutria, Pescado, and Ojo Caliente, where spring-fed reservoirs and canal and ditch systems facilitated some irrigated crop production (Figure 1). The combination of floodwater and irrigated fields spread risks and improved the likelihood of obtaining sufficient maize yield to supply Zuni current needs and maintain a two-year reserve. Surplus maize was traded with other Native communities, the U.S. military, settlers, and other emigrants during the mid- to late nineteenth century (Hart 1995). By the late 1800s, the traditional territory used by the Zuni had been reduced by 60% to some 2.5 million ha (Cleveland et al. 1995; Hart 1995). At the beginning of the twentieth century, 52% of cultivated land was runoff farmed (Graham 1990; Hart 1995).

Early twentieth-century federal government programs initiated large dam and irrigation projects with the intent of assimilating and transforming Zuni agriculture into the irrigated agriculture norm of the western U.S. (Worster 1985). These programs shifted agriculture from primarily traditional valley margin

fields to the floodplains, which tend to have poorer soils (including highly clayey or sodic soils) and are more prone to frost. Spring-fed irrigated agriculture had been traditionally practiced along the main valleys, but the government-imposed programs radically altered and disrupted traditional Zuni agriculture. Most Zuni moved into the Pueblo of Zuni or Blackrock, leaving few people in the outlying farming villages. Extensive erosion and gully or arroyo downcutting during the late nineteenth and early twentieth centuries further restricted floodwater farming in some areas (Hart 1995). Beginning in the 1930s, many areas that had been runoff farmed became grazing lands in response to federal policies favoring livestock production over farming. By 1935, reservation lands consisted of only 137,700 ha, with just 2100 ha cultivated. Gradually the local economy shifted from reliance on agriculture to wage labor. Although some Zuni continued their customary agricultural practices, most Zuni held non-agricultural jobs, raised livestock, and/or focused their farming efforts on conventional irrigation, producing alfalfa and other forages for cattle and sheep. During the twentieth century, traditional agriculture and knowledge were largely disregarded, and traditional runoff agriculture declined greatly (Cleveland et al. 1995; Hart 1995). By the early 1990s, fewer than 600 ha were cultivated, with just 18% of the cultivated land still runoff farmed (Graham 1990; Hart 1995). Despite disruptions and changes, maize production still plays a vital role in Zuni culture and some traditional runoff maize production persists (Bohrer 1960; Manolescu 1994; Norton et al. 1998; Pawluk 1995).

During the last decade, environmental, cultural, and economic concerns led to the formation of the Zuni Conservation and Sustainable Agriculture Programs, made possible by the Zuni Conservation Act of 1990; the Act resolved the Zuni lawsuit against the U.S. government for land damages resulting partially from forced agricultural and other land use changes (Hart, 1995). These tribal programs were established, in part, to revitalize traditional agricultural practices. As part of that effort, a series of agroecological studies were undertaken to better understand the function and structure of Zuni traditional runoff agriculture (Havener 1999; Homburg 2000; Norton 2000; Sandor et al. 1999). Specific objectives of the study reported here were to:

1. Document contemporary Zuni runoff crop production practices; and
2. Explore the general relationships among management, field characteristics, and maize productivity.

MATERIALS AND METHODS

Fields.—Field characteristics, production practices, and productivity of four runoff fields of Zuni farmers were documented. The study focused on these four fields for several reasons:

- A rapport with the farmer-cooperators had previously been established;
- Fields were actively cultivated in 1998; and
- Fields were located in the farming districts of Pescado and Nutria, prehistorically and historically important farming areas of the reservation (Figure

1). Controlled cropping experiments and other portions of the larger agroecology study were also located in these districts.

Weather Data.—A Campbell Scientific remote weather-precipitation station was installed at one of the controlled cropping experiment fields located in the Bear Canyon unit of the Nutria farming district (Figure 1). Daily minimum and maximum air temperatures and rain events were recorded for May 20 through August 21. Two funnel and collection devices were installed adjacent to each of the two experimental fields to measure rainfall and to sample precipitation for nutrient content.

Soil Information.—Fields were situated on alluvial fans, the traditional setting of runoff fields. Each field was subdivided into three areas based on alluvial fan position: upper, middle, and lower fan. In each fan position of each field, four surface soil samples were collected from the upper 15 cm, approximating the depth of the plow zone; these four samples were combined and a subsample of the composite was analyzed. The Nutria field surface soil sampling, conducted as part of the larger agroecology study, used a different sampling scheme in that samples were collected along two transects in the center of the field (Homburg 2000). Surface samples were analyzed for soil texture, pH, nitrate-nitrogen, plant-available phosphorus, and organic matter content; potassium was not determined because it is usually not limiting in the soils of this region (Sandor and Gersper 1988).

Soil profiles were described and classified according to standard methods (Soil Survey Staff 1993, 1999) in 1 × 1 m or 1 × 2 m pits excavated to a depth of 0.75 to 1.5 m in each field.

Particle size distributions were determined using the sieve and pipette method (Klute 1986: Method 15.4) with samples pretreated with a 30% hydrogen peroxide reagent for digestion of organic matter and a sodium hexametaphosphate solution for clay dispersion.

Chemical analyses were performed by the Iowa State University Soil Testing Laboratory. Air-dried soil samples were sifted through a 2-mm sieve in preparation for analyses. Soil pH was measured electrometrically using a 1:1 suspension (weight basis) of soil and distilled water using a glass electrode (Page et al. 1982: Method 12-2.6). Available phosphorus was measured using the Olsen extraction method (Page et al. 1982: Method 24-5.5.20; extract of 0.5 M $NaHCO_3$ at pH 8). Nitrate-nitrogen was determined colorimetrically (Page et al. 1982: Method 33-8). Percent organic matter was determined by combustion (Page et al. 1982: Method 29-4).

Field Management.—Fields were managed by the farmers in their usual ways to produce their traditional, open-pollinated maize cultivars and other crops. Wilmer Quandelacy and his brothers manage the Elk, Nutria, and Bear Canyon fields. Stanley Sanchez and Carmichael Laiwakete manage the Pescado field.

Information was obtained primarily through in-field visits and discussions with the farmers during the 1998 growing season. Information collected for each field included recent field history; specific crops and cultivars grown, and seed

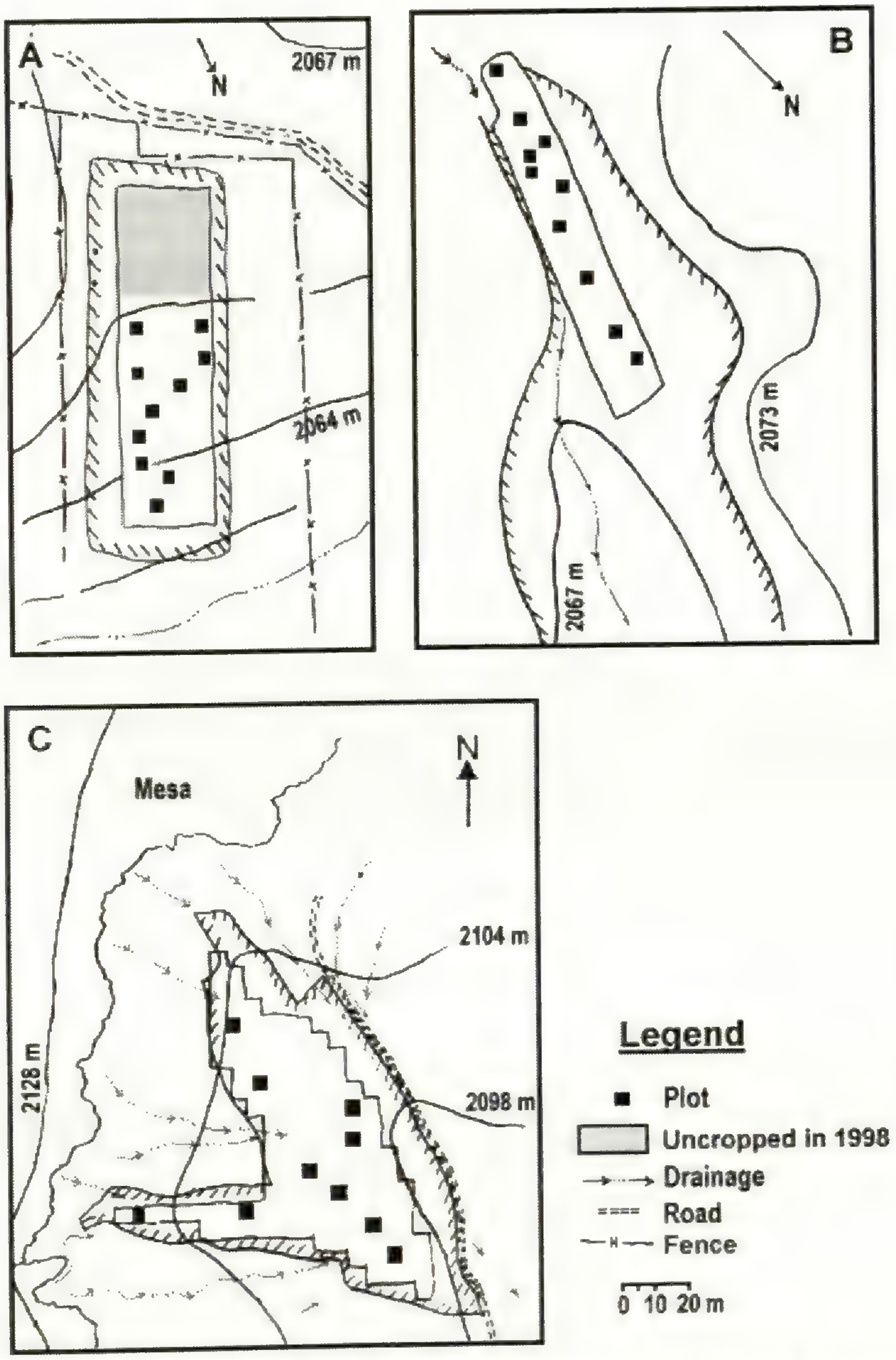


FIGURE 2.—Field maps showing drainages and approximate locations of plots within each field. Each plot is 5 × 5 m. a) Nutria; b) Bear Canyon; and c) Elk fields. Pescado field is not shown. Maps are oriented with upslope shown at the top. (Original maps by Troy Lucio.)

sources; planting date, depth, and method; harvest date; tillage; water and soil management; and weed and pest management practices.

Maize Data.—Each field was mapped and divided into a grid of 5 × 5 m areas ("plots"), with each plot assigned an identifying number. Plots were selected to obtain a representative sampling of each field (Figure 2):

1. Each field was stratified into large sections based on alluvial fan position and other field features;
2. To obtain a representative sampling of each part of the field, two to four numbers were randomly drawn from a pool containing all of the plot numbers within each stratified section of the field, for a total of ten plots per field.
3. Where a selected plot was at the field margin, the next adjacent plot towards the interior of the field was substituted to diminish any edge or border effects.
4. In fields intercropped with other crops, only those plots also containing maize were sampled.

The ten selected plots in each field were outlined with flagging tape or string to facilitate monitoring throughout the growing season.

Maize data were collected from each of the ten plots in each field. These data included stand density, total number of ears, and grain yield of each plot. Maize population density was determined in late July and early August by counting and multiplying the total number of hills and number of plants in five random hills in each plot: Plants/plot = (number of hills/plot) × (mean number of plants in five hills in the plot).

Weed pressure was visually estimated relative to crop plants growing in the field. Weed pressure ratings were defined as:

- "Minimal"—About 25% or less of the plants growing in the field were weeds (i.e., non-crop species);
- "Moderate"—Weeds comprised approximately half of the plants in the field; and
- "Severe"—Weeds were the dominant vegetation in the field.

Harvest occurred on 6, 7, and 9 October 1998. Only those ears deemed sufficiently mature by the farmers were included in the harvest. Harvested ears were counted, dried, hand-shelled, and grain weighed to determine yield. Ears lacking any harvestable grain were not included in the count of number of ears per plot.

Statistical Analysis.—Summary statistics, correlation coefficients, and coefficients of variation (CV) were calculated using the standard functions in Microsoft Excel® 2000. Data are reported as means and standard error (± SE).

RESULTS AND DISCUSSION

Zuni farmers report that maize, beans, squash, and melons are produced for household consumption, to share with community members, to generate seed, to maintain land use rights, and because farming is a time-honored activity (Bohrer 1960; Brandt 1992; Manolescu 1994). Crop production, however, is not the primary economic activity of most Zuni farmers today, including the farmer-cooperators in this study (Brandt 1992; Cleveland et al. 1995; Manolescu 1994). Farmers note that fields are often left unplanted due to the lack of time, water, equipment, or other production constraints. Although these constraints also often limit their

farming activities, the farmers in this study plant maize in one or more fields every year.

One farmer and his family have fields in both the Pescado and Nutria farming districts, whereas the other farmer-cooperators have several fields in different landscape settings in the Pescado district. Most Zuni farmers have two or more fields, often in different parts of the reservation (Manolescu 1994). The use of scattered multiple fields traditionally served to buffer the agricultural system against crop failure (Cleveland et al. 1995; Ferguson and Hart 1985). Overall yield stability results from differences in growing season conditions (moisture and temperature), soils, and pests among diverse field locations.

Field Characteristics.—Farmers in this study report that field selection is based on several criteria:

- land use rights;
- probability of the field receiving sufficient water to support crop production; and
- field size and qualities, including soil texture and natural vegetation.

In addition, one farmer specifically avoids areas with sparse or weedy vegetation. These location criteria are consistent with those reported by others (Cleveland et al. 1995; Cushing 1974; Ferguson and Hart 1985; Kintigh 1985; Manolescu 1994; Norton 2000; Pawluk 1995; Prevost et al. 1993).

The four fields studied are situated to receive storm floodwaters from upslope. One of the two fields in each farming district studied was situated in an upper alluvial fan and the other field was located more distally on a fan.

Mean elevation of these four fields is 2079 m. Known fields in the Pescado and Nutria areas are concentrated between 2000 and 2150 m elevation. Zuni and Navajo have farmed a few sites in the area at elevations up to 2250 m (Ferguson 1985; Rhode 1990). In an archaeological survey of Zuni agricultural sites, Rhode (1990) found that the majority of sites occur between 2010 and 2075 m, with an overall range of 1950 to 2250 m. Cold temperatures ordinarily make the growing season length too short for maize production at elevations much above 2200 m in this region (Brandt 1995; Sandor 1995).

Historically, the cropped area of these fields was substantially greater than the area cultivated in 1998 (Table 1). The cultivated area of these fields averaged 0.69 ha (± 0.37); the three fields managed by one family averaged 0.32 ha. Most Zuni fields today are an estimated 4 ha or less (Manolescu 1994). Farmers indicate that time constraints limit the area that they can manage. In addition, they note that periodically leaving fields or sections of fields uncropped for several years is important to maintain field productivity. Generally, fields or parts of fields are cropped for two or three years and then left fallow for one to four or more years. Across the reservation, we observed that fields cropped for more than several consecutive years tended to exhibit nutrient deficiencies. The effectiveness of fallowing to accumulate nutrients or disrupt pest cycles depends on the length of the fallow period and the field's vegetation during the fallow period.

Bear Canyon field was in its second consecutive year of cropping; the farmer estimated that it had been fallow for the previous 10 to 12 years. The Nutria field

TABLE 1.—Field locations and physical environments.

Field name	Farming district	Landform	Watershed size (ha)	Field elevation (m)	Field size (ha)	1998 Cultivated area (ha)	Slope (%)
Bear Canyon	Lower Nutria (Bear Canyon Unit)	upper alluvial fan	39	2067	2.9	0.3	3
Nutria	Lower Nutria	lower fan	52	2070	13.8	0.3	5
Elk	Pescado	upper fan	28	2100	0.4	0.4	3
Pescado	Pescado	middle fan	120[1]	2080	2 to 7[2]	1.8	3

[1] Data from Norton (1996:62).
[2] Data from Graham (1990:99). Historically, the cropped area of this field has ranged between 2 and 7 ha.

had been cropped for about five consecutive years. Crop production at the Pescado field rotates every couple of years between two large sections; the section cropped in 1998 was in its second successive year of production. To the farmers' knowledge, Elk field had not been cropped before they cleared the site of sagebrush and pinyon for the 1997 growing season. This new field was developed because the farmer wanted to try a new site and this one satisfied his criteria: the family had land use rights to the site; he had observed that water flowed onto the site from two directions; it had sandy surface soil and vigorous, but not weedy, vegetation; and it was accessible by truck. With the exception of Elk field, historical and archaeological evidence indicate that the other three fields have been cropped occasionally since at least A.D. 1000 (Homburg 2000).

Soil classification and physical properties. Soils in most of the fields are classified as Alfisols, and all four fields have loamy to sandy surface textures (Table 2). Among his selection criteria, one farmer evaluates potential field sites based on soil texture, favoring those with sandy surface soils. Medium to moderately coarse surface soil textures, such as sandy loam and loams, are well suited for crop production because of their favorable water infiltration and water-holding properties, aeration, and plant-available nutrients (Brady and Weil 2002). Surface soil particle size sorting was evident in each field, generally resulting in coarser textures in the upper field areas with clay and silt increasing and sand decreasing downslope (Table 2). Fields situated more distally on alluvial fans exhibited nearly twice the clay content in the upper 15 cm than did fields located on upper alluvial fans, averaging 24% and 13% clay, respectively. The trend of coarser to finer particle sizes from upper to lower parts of alluvial fans agrees with observations from other studies at Zuni (Homburg 2000; Norton 1996; Pawluk 1995) and with general knowledge of alluvial fan geomorphology (e.g., Waters 1992).

Stratification in the soil profile of each field demonstrates recurring depositional events interspersed with soil horizons marking periods of geomorphic stability (Homburg 2000). Soil development is indicated by the accumulation of illuvial clay, forming argillic horizons. Elk field is a good example of a field having younger, coarser alluvial fan sediment overlying stratified alluvium and a buried argillic horizon. Compared to its overlying topsoils, plant available moisture was 57% greater on a relative basis, and 7% greater on an absolute basis in argillic

TABLE 2.—Surface soil (0–15 cm) physical properties and soil taxonomic classification of fields.

Field name	Relative field position of surface sample	Sand content (%)	Silt content (%)	Clay content (%)	Textural class	Soil classification (Family)
Bear Canyon	upper	72.5	18.0	9.5	sand loam	Fine-loamy, mixed, mesic, Aridic Haplustalf[2]
	mid-field	69.9	18.9	11.2	sandy loam	
	lower	51.8	32.0	16.1	loam	
	Mean	64.7	23.0	12.3		
Nutria[1]	upper mid-field	49	30	21	loam	Fine-loamy, mixed, mesic, Aridic Haplustalf
	upper mid-field	21	49	30	clay loam	
	mid-field	41	36	23	loam	
	mid-field	16	52	32	silty clay loam	
	Mean	32	42	26		
Elk	upper	74.3	15.3	10.4	sandy loam	Coarse-loamy, mixed, nonacid, mesic, Aridic Ustifluvent with buried argillic horizon
	mid-field	66.1	17.2	16.7	sandy loam	
	lower	61.3	25.9	12.8	sandy loam	
	Mean	67.2	19.5	13.3		
Pescado	upper mid-field	55.6	26.6	17.8	sandy loam	Fine-loamy, mixed, mesic, Aridic Haplustalf. Minimally developed argillic horizon
	mid-field	45.7	34.5	19.8	loam	
	lower	28.6	45.0	26.4	loam	
	Mean	43.3	35.4	21.3		

[1] Data from Homburg (2000:240).
[2] Soil profile excavated about 100 m downslope on same alluvial fan as cultivated field.

horizons in the Pescado field (Homburg 2000:98). Fields having soil profiles with coarser textured surface layers underlain by argillic horizons would favor crop production in runoff systems. The stratification and argillic horizon help retain moisture within the crop rooting zone. The coarser surface promotes rapid water infiltration, and the underlying more clayey zone holds water in the root zone, reducing percolation losses (Homburg 2000; Sandor 1995). In addition, a coarser surface reduces evaporative losses due to the larger pore size and concomitant reduced upward capillary movement of water.

Zuni clearly recognize the relationship between soil moisture and soil texture (Norton 2000; Pawluk 1995). Cushing (1974:181), writing in the 1880s, noted that "... the little drifts of sandy soil protect the underlying loam in which the kernels are embedded. . . ." Other Native Americans in the region similarly select runoff fields with coarser surface layers underlain by more clayey zones, including the Tohono O'odham (Nabhan 1984) and Hopi (Bradfield 1971; Hack 1942; Prevost et al. 1984).

Soil chemical properties. Farmers in this study do not apply synthetic fertil-

TABLE 3.—Surface soil (0–15 cm) chemical properties by relative field position.

Field name	Relative field location of surface sample	pH	Available P (mg/kg)	Nitrate-N (mg/kg)	Organic matter content (%)
Bear Canyon	upper	7.0	2	12	1.8
	mid-field	6.9	4	21	1.9
	lower	7.0	<1*	7	2.8
	Mean	7.0	2	13	2.2
Nutria	upper mid-field	8.0	8	19	2.5
	upper mid-field	7.8	6	34	3.8
	mid-field	7.9	7	13	2.7
	mid-field	7.8	6	18	4.5
	Mean	7.9	6	21	3.4
Elk	upper	7.0	6	13	1.2
	mid-field	7.1	2	8	0.9
	lower	6.6	1	23	1.7
	Mean	6.9	3	14	1.2
Pescado	upper mid-field	7.6	6	10	1.7
	mid-field	7.5	6	17	2.1
	lower	7.1	8	26	3.5
	Mean	7.4	6	18	2.4

* Available P in this sample was below detectable level and treated as zero in calculation of field mean.

izers or manure to their fields; throughout the Southwest, fertilizer amendments are generally not used in traditional systems (Sandor 1995). Because horses are pastured in the Pescado field following harvest and cattle are sometimes grazed in the Nutria field, these fields receive some minimal manure input; other fields may be occasionally grazed by sheep. These farmers, however, attribute the fertility of their fields to storm runoff and materials it deposits on the fields, and to periodic fallowing. The contribution of runoff to soil fertility has been recognized by generations of Zuni (Cushing 1974; Manolescu 1994; Pawluk 1995). Cushing (1974) described Zuni management of storm runoff for the express purposes of not only irrigating the crop, but enriching the soil as well. This important relationship between landscape processes and soil qualities is also embedded in Zuni soil terms; for example, the Zuni word for the materials transported by runoff translates to "tree soil," recognizing the upslope source of the organic debris (Pawluk 1995).

Soil and nutrient analyses showed that the four fields have optimum to somewhat alkaline pH for maize growth and adequate macronutrients for these low crop density systems. Average soil pH in the upper 15 cm of the four fields is 7.3 (± 0.2) (Table 3). Twelve Zuni field areas surveyed by Manolescu (1994) exhibited somewhat higher pH, ranging from 7.2 to 7.7, and averaging 7.5. Optimum pH for maize is between 5.5 and 7.0 (Olson and Sander 1988).

Nitrate-nitrogen, a plant-available form of N, of the four fields averaged 16.5 mg/kg (± 1.8), and available P averaged 4.3 mg/kg (± 1.0) (Table 3). Nitrate-nitrogen in each of these fields was considerably greater than, and available P

was similar to, that reported for 12 other Zuni farmer fields, which averaged 4.9 mg/kg nitrate-nitrogen and 5.9 mg/kg available P (Manolescu 1994). Soils of the controlled experiment fields of the larger agroecology study had 8.5 mg/kg available P (Homburg 2000); nitrogen mineralization studies of these soils showed average nitrate-nitrogen of 2.6 (± 0.4) to 22.2 (±1.4) mg/kg at 0 and 70 days incubation, respectively, and average ammonium, another plant-available form of N, ranged from 2.3 (± 0.1) to 0.5 (± 0.0) mg/kg at 0 and 70 days incubation, respectively (Carl S. White, unpublished data[1]). Available N varies during the season with moisture, temperature, and microbial activity (Brady and Weil 2002). Although maize in this system is planted deeply, it is likely that roots are present in this upper soil layer. Maize adventitious roots, arising from basal nodes of the stem, are commonly located near the soil surface regardless of seeding depth; adventitious roots were observed in Zuni maize. These roots extract nutrients and water from upper soil layers.

Specific crop nutrient requirements in many soils in the Southwest are not well understood. The amounts of nitrate-nitrogen and available P at each field are interpreted as moderate and low, respectively, based on the nutrient requirements established for conventional commercial agricultural production in New Mexico; conventional systems, however, require relatively higher amounts of nutrients to support higher plant population densities and high yields. Nitrate-nitrogen amounts between 10 and 30 mg/kg are considered moderate (Cihacek et al. 1992). Available P levels below 8 mg/kg are rated as very low. In Arizona soils, however, available P levels greater than 5 mg/kg are considered sufficient (Doerge 1985). The lack of nutrient deficiency symptoms in the farmers' fields, with the exception of the Pescado field, suggests that nutrient levels were adequate to support these low-density crops (9650 plants/ha). Maize plants in the Pescado field were stunted and displayed symptoms of P deficiency, likely resulting from severe weed competition for both nutrients and water. When water becomes limiting, nutrient uptake can become restricted.

Agricultural soils in semiarid environments are commonly deficient in N (Ludwig 1987; Nabhan 1984; Sandor and Gersper 1988; West 1991). In this runoff agricultural system, however, storm flows transport organic matter, sediments, and nutrients to fields. As water flows over the landscape, nutrients are dissolved and transported. Analyses of runoff water collected at the controlled experiment fields indicate that these waters deliver N and other nutrients from the watershed to the field (Norton 2000). In addition, precipitation itself contributes plant usable forms of N (nitrate-nitrogen and ammonium) to the system (White and Thomas 1999).

Soil organisms and watershed vegetation also likely contribute to the nutrient status of the fields (Havener et al. 1999). Soil microbial biomass did not differ significantly between cultivated and uncultivated soils at Zuni, contrary to the trend of decreased microorganisms in conventional production fields in the U.S. Corn Belt (Havener 1999). Field-grown Zuni maize roots exhibit substantial amounts of mycorrhiza formation. Nutrient uptake of some unimproved maize cultivars can be enhanced by mycorrhizae (Khalil et al. 1994); the effect of mycorrhizal infection on Zuni maize has not been tested. Vegetation mapping of watersheds above fields in the Pescado and Nutria districts, including the Pescado

field watershed, revealed the common occurrence of symbiotic nitrogen-fixing plants: lupine (*Lupinus* spp.), scurfpea (*Psoralea tunuflora*), deer vetch (*Lotus wrightii*), and mountain mahogany (*Cercocarpus montanus*), actinomycete nodulated vascular plants, and cryptogamic crusts (Havener 1999; Homburg 2000; Norton 1996). Symbiotic soil bacteria that associate with legumes convert atmospheric N into a form usable by plants. Cryptogamic crusts are a symbiotic associations of fungi and algae that also fix N. Cryptogamic crusts are important sources of N in semiarid ecosystems (Metting 1991). In addition to nutrients dissolved in runoff water, the organic debris deposited on fields by storm flows provides nutrients as the debris decomposes (Norton 2000).

Organic matter averaged 2.3% (± 0.5) by mass. Typically, soils developed in semiarid zones are low in organic matter, near 0 to about 3 or 4% (Klemmedson 1989). Organic matter contributes to soil water-holding capacity and nutrient availability for crop production (Brady and Weil 2002).

Based on his fieldwork in the early 1880s, Cushing (1974:164–166, 181) noted the importance of runoff to renew soil fertility and the use of an in-field fallowing system in which the new crop was planted about 10 to 12 cm east of the previous years' row of crop stubble to avoid successively planting in the same place. The stubble also served as a windbreak, causing wind-blown sediment to be deposited on the leeward side of the stubble. Wind barriers of brush were erected on the western edges of fields to promote accumulation of eolian sediment. These windbreaks may also have reduced seedling desiccation by the dry spring winds. Zuni have long understood the dynamics of landscape processes relative to crop production.

Precipitation and Runoff.—Summer rains in the Pescado and Nutria districts in 1998 occurred in a typical pattern, beginning in early July. Rain events were noted, but amounts were not recorded at the farmers' fields. Mid-May through mid-September 1998, 170 mm and 175 mm rain was received at the controlled experiment fields located in the Bear Canyon and Nutria areas, respectively, about 10 to 12% above average; mean precipitation for this period near Blackrock is 155 mm (Kintigh 1985). These rain amounts, however, are near the lower limit for maize production.

Maize is generally produced in areas receiving at least 250 mm precipitation annually, or 150 mm during the growing season (Shaw 1988). To produce high yields, maize requires an estimated total of 500 to 800 mm water during the growing season (Critchley and Siegert 1991). Daily consumptive water use can average more than 6 mm in semiarid to arid climates (Rhoads and Yonts 1984); at Clovis, New Mexico, maize potential daily water use rates range from 7.5 to 9.8 mm/day (Abdul-Jabbar et al. 1983). The actual amount of growing season rain needed for productivity, however, varies with the specific maize cultivar, root length density, plant population density, growing season length, stored soil moisture, rain temporal distribution relative to crop developmental stages, atmospheric water demand (which depends on solar radiation, temperature, wind, and humidity), and irrigation or other water supplements. Greater yields are generally obtained with greater moisture availability (Rhoads and Bennett 1990). The mois-

FIGURE 3.—Runoff components: a) runoff water; b) debris and sediments washed into field with storm runoff; c) sediments deposited on field; and d) debris caught by maize hill.

ture requirement or responsiveness of Zuni maize has not been specifically examined.

Rain was sufficient to generate two runoff events at the Pescado and Nutria fields, three at the Elk field, and two or three at the Bear Canyon field (after some storms, muddy roads prevented field access to check for runoff). After each runoff event, an assortment of debris was observed on the field. Storm runoff water washes sediments and organic materials in various stages of decomposition into fields from upslope; such materials often accumulate around the bases of maize hills (Figure 3). The frequency of summer runoff events observed in 1998 corroborate farmers' perceptions of the usual number of such events on their respective fields: one or more at Pescado, and two to three events at the other fields.

Runoff amount and frequency is a function of the area of the watershed, the amount and intensity of the rainstorm, slope, soil permeability, type and density of vegetative cover, surface litter or stones, and antecedent soil moisture (Shreve 1934). In arid regions, smaller watersheds have a greater frequency of runoff events and greater runoff yield per unit area (Osborn and Renard 1970). The number of runoff events observed in 1998 in these fields is consistent with the

general inverse relationship between watershed area and runoff frequency in arid environments. Elk and Bear Canyon fields have smaller watersheds than the Nutria and Pescado fields and would be expected to have more frequent runoff events with greater water yield (Table 1). The effective size of the Nutria field watershed, however, is reduced by a road perpendicular to the slope, about 100 m above the field; the road interrupts storm flows from upslope, channeling runoff away from the field. Elk field is situated at the confluence of multiple ephemeral waterways near the base of a mesa, increasing its opportunity for runoff. Runoff events at Bear Canyon had sufficient volume and velocity to cause some plant washouts and soil erosion; damaged plants were propped up by "hilling" to improve plant standability against wind and flood. Zuni farmers, like other Native American farmers, traditionally hilled or pushed soil up around the base of maize plants as they hoed weeds, adding structural strength to the plant cluster (e.g., Biggar 1918; Castetter and Bell 1942:175; Cushing 1974:203; Will and Hyde 1917:83; Wilson 1987:26). Although hilling was observed in some Zuni fields, the farmers in this study did not routinely hill because of time constraints. To slow water velocity and reduce the risks of washouts and erosion, the farmer later installed earthen berms and brush and rock barriers in the Bear Canyon field. The other three fields in this study had no current water or erosion control structures. Control structures were observed in other cultivated and uncultivated Zuni fields. Traditionally, runoff was actively managed with control structures to keep large debris off the field, to slow water to promote infiltration, and to reduce erosion and plant washouts (Brandt 1995; Cushing 1974; Ferguson and Hart 1985; Kintigh 1985; Norton and Laahty 1999).

Direct rain, together with storm floodwaters, apparently provided adequate water to support the crop in the Elk and Bear Canyon fields; maize plants in these fields exhibited mild wilting for only brief intervals. Nutria and Pescado fields showed water-deficit stress symptoms more often and for longer durations, apparently because of less water and greater interplant and/or weed competition; the Nutria field had a relatively high plant population density, and both fields had greater weed pressure than the other fields.

Production Practices.—Crop management today is commonly determined by availability of time, equipment, and transportation to the fields (Brandt 1992; Manolescu 1994). Each of the fields is at least 30 km from the Pueblo of Zuni, where the farmers reside. Maize production is important to these farmers, but it is not their main economic activity. As a result, production practices varied somewhat among farmers and fields, with some fields receiving more attention than others. One of the main objectives of cropping the Pescado field was to retain use rights and for pasturing horses after the maize harvest; management of this field was limited to field preparation, planting, and harvesting. The stated reasons for cropping the other fields were to obtain sufficient maize to satisfy the family's needs, produce seed for the next season and to share with other community members, and because farming is enjoyable.

Maize cultivars. Farmers in this study usually produce at least two Zuni folk varieties of open-pollinated maize; these cultivars have a mix of flinty and floury endosperms. Farmers define maize type based on kernel color. Both white and

blue maize were produced in each of the four fields; these are the most common types grown at Zuni (Bohrer 1960; Brandt 1992; Manolescu 1994). Zuni red maize and sweet corn were also planted in the Pescado field.

Farmers report that the type and amount of maize they plant depends on need. Grain is used for direct human consumption, ceremony, and seed; vegetative parts are used for livestock fodder. Like most Zuni farmers, these farmers save their own seed from year to year, occasionally obtaining seed from other community members. Some Zuni farmers also obtain seed from other Native American communities in the area, including Hopi and Acoma. Nearly 75% of 50 Zuni households surveyed grow Zuni folk varieties of maize (Brandt 1992); these cultivars are believed to perform better than commercial varieties or those obtained from the Rio Grande pueblos in central New Mexico.

Different maize types were sown in different parts of each of the fields monitored. Sweet corn was planted in the center of the Pescado field to "hide" it from the elk and other herbivores. Planting the maize types separately in a field is a matter of convenience (Figure 4). Farmers do not consider cross-pollination among maize types a problem because the types "do not mix;" we observed that these types tend to flower at different times, which reduces the probability of cross-pollination among cultivars.

Planting practices. Fields were planted between 13 May and 1 June 1998. These farmers prefer to plant earlier, as early as temperatures permit, and consider early June to be the latest for planting maize. Other farmers also report that planting occurs as early as mid-April and should be complete before June (Manolescu 1994). During the late nineteenth century, Zuni commonly planted in May (Cushing 1974:174). Temperature and water-deficits are the main production constraints at Zuni and throughout the southwestern U.S. Planting as early as temperatures permit increases the likelihood of sufficient moisture availability for germination and emergence, and attainment of crop maturity before fall frost.

Cold temperatures delimit the growing season at Zuni. In the eastern part of the reservation, the growing season ordinarily extends from late April or early May through late September or early October. The temperature range for normal maize growth is approximately 8 or 10 to 40°C, with optimum growth occurring at about 30°C, assuming water is not limiting (Shaw 1988). Maize usually survives at ambient temperatures between −4 and 50°C, although injury will occur at either temperature extreme. Although temperatures may remain above freezing, spring temperatures at Zuni are often cool and early summer frosts are not uncommon at these elevations (about 2000 to 2150 m). Frost occurred in the Nutria farming district as late as July 1 in 1997 and June 19 in 1998, causing some tissue damage but not plant death.

Mean daily air temperature for the 1998 growing season at the controlled experiment field located in the Bear Canyon area was relatively cool, 16.8°C; season mean daily maximum and minimum temperatures were 27.3 and 6.4°C, respectively. May through September mean temperature at Blackrock is 18.6°C (Kintigh 1985). Maize generally requires a summer average minimum temperature greater than 13°C (Shaw 1988). Because of frequent exposure to cool temperatures over generations, Zuni maize has likely evolved mechanisms that confer cold tolerance; cold tolerance of these cultivars has not been documented.

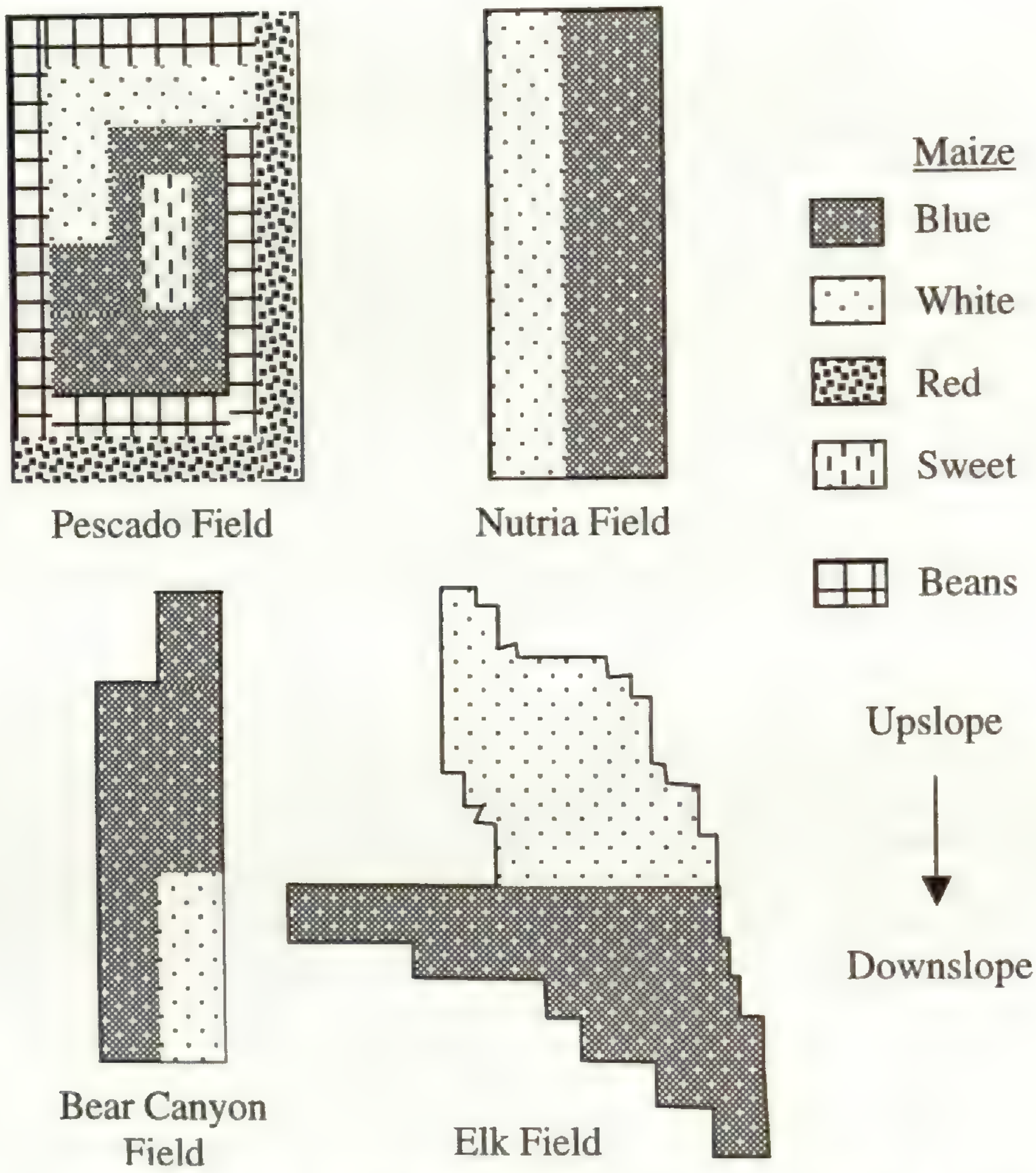


FIGURE 4.—Schematics of the planting patterns by maize cultivar type in the Nutria, Pescado, Bear Canyon, and Elk fields, 1998. Pinto bean, watermelon, and pumpkin were interspersed randomly in the Bear Canyon field; pinto bean was planted in one of the "circles" of the Pescado field. Not to scale.

Temperature has a direct effect on the rate of development, with cooler temperatures slowing and warmer temperatures hastening growth and development. Depending on temperature fluctuations, the number of days needed to attain maturity can vary widely from year to year. The cultivars produced in this study required about 125 days to attain maturity. Although Zuni blue maize produced in the experimental fields has a reputed maturity range of 95 to 120 days, nearly 130 days from planting was required to reach maturity in 1998 (Muenchrath, unpublished data). Cool soil temperatures at planting may have hindered germination and emergence, and the relatively cool air temperatures likely slowed developmental processes and delayed maturity. Hopi maize, adapted to northeastern Arizona and commonly traded with Zuni, matures in 115 to 130 days (Bradfield 1971).

All four fields were prepared for planting by plowing. The Pescado field was disked after plowing, creating a rough seedbed with many large clods. While disking, the driver planted seed by dropping two to three kernels at a time from

TABLE 4.—Production practices as reported by farmers or measured. Bear Canyon, Nutria, and Elk fields are managed by a single extended family; Pescado field is managed by two other farmers.

Field name	Planting date 1998	Zuni maize (seed color or type)	Planting depth (cm)	Seeds planted per hill (number)	Hill spacing, approx. equidistant	
					Stated (m)	Actual[2] (m)
Bear Canyon	June 1	blue and white	15	4	1.5 to 2.5[1]	1.3
Nutria	May 15	blue and white	15	4	1.5 to 2.5[1]	0.6
Elk	May 13	blue and white	15–20	4	1.5 to 2.5[1]	1.1
Pescado	May 25	blue, white, red, and sweet	15–30	2–3	Unsure	3.7

[1] Farmers reported hill spacing as "3 to 4 steps," a distance estimated to be equivalent to about 1.5 to 2.5 m.
[2] Actual hill spacing calculated from mean hill density per plot.

his hand, beginning in the middle of the field and proceeding in concentric passes. Seed type was changed wherever the seed supply of one type ran out (Figure 4). The Bear Canyon and Elk fields were also planted by the tractor driver dropping about four seeds together into the furrow opened during the previous pass of the plow and adjacent to the tractor. In the Nutria field, people walking behind the tractor hand planted maize, usually placing four kernels together into the side or bottom of the furrow, wherever the soil seemed "softer." Seed is covered as the next furrow is plowed. Nutria and Elk fields were harrowed the day after plowing and planting to break up soil clods, to better cover seed, and to smooth the field surface; the farmer was unable to get to the Bear Canyon field to harrow it. Other Zuni farmers use similar field preparation and planting practices, sowing two to five seeds per cluster (Manolescu 1994).

Traditionally maize was sown by hand using a digging or planting stick to open a hole in the soil for seed placement (Cushing 1974:175). Farmers recognize that this traditional 'no-till' approach conserves soil moisture by limiting the soil volume opened and exposed to the dry, windy conditions (Ford 1985). Soil moisture accumulated during the winter is relied on for germination and seedling establishment. Zuni springs are usually dry and windy, reducing moisture availability as the season progresses until the summer rains arrive, usually in July. Cushing (1974:181) wrote that the ". . . country of the Zunis is so dry that the seeds have to be planted to great depths—even at the expense of great delay in their growth," usually at about 10 to 18 cm; 12 to 20 kernels were planted in each hole, in part, because it was expected that some would not emerge successfully. Collins (1914:299) notes that ". . . there is no fixed depth for planting, the custom being to plant deep enough to place the seed in moist soil," commonly at depths of 15 to 45 cm. Although the desired planting depth is still based on the location of moist soil, actual planting depth is now largely determined by plowing depth; fields were plowed to depths of 15 to 40 cm and seed planted at 15 to 30 cm in this study (Table 4). Manolescu (1994) reports that 8 to 20 cm is the common planting depth used at Zuni today.

Seeds will not germinate in dry soil. Thus, farmers are reluctant to risk seed

TABLE 5.—Mean plants per hill, hills per plot, and estimated plants per plot and resulting plant population density. Standard error indicates the variability among plots within field.

	Plants per hill		Hills per plot		Estimated[1] plants per plot		Estimated[2] population density (plants/ha)	
Field name	Mean	± SE	Mean	± SE	Mean	± SE	Mean	± SE
Bear Canyon	1.9	0.2	10.5	0.7	20.7	3.1	8,288	1,229
Nutria	2.4	0.2	18.4	2.9	45.6	8.2	18,248	3,298
Elk	2.0	0.2	11.1	0.9	23.5	3.6	9,384	1,422
Pescado	1.1	0.1	6.1	1.1	6.7	1.1	2,680	448
Across Fields:	1.9	0.1	11.5	1.1	24.1	3.2	9,650	1,281

[1] Calculated with the formula: Estimated plants/plot = [(mean number of plants in 5 random hills/plot)(hills/plot)].

[2] Calculated from the mean of 10 plots in each field: Estimated field population density = [(mean estimated number of plants/plot)(25 m^2/plot)(10,000 m^2/ha)].

if conditions are dry. Planting decisions are often dependent on spring soil moisture; some Zuni farmers assess soil moisture conditions in March by digging a test hole in the field (Carol Brandt, personal communication 2001[2]). When soil conditions are dry in the plow zone, the farmers in our study sometimes soak seed overnight to two days in spring water to hasten germination. Seed were soaked before planting at the Elk and Nutria fields in 1998. Soaking seed before planting, however, did not provide a significant increase in plant population density relative to fields planted with dry kernels (Table 5). Although not mentioned by the farmers in this study, other farmers indicate that seed is soaked to speed germination when planting is relatively late (Manolescu 1994). Neither Cushing (1974) nor Collins (1914) report that Zuni traditionally soaked seed before planting.

In addition to moisture availability, deep planting (greater than the 5 cm commonly used in commercial maize production systems) may provide other benefits to the crop. Deep planting can extend the growing season in the spring. Because the sensitive growing point, or meristematic region, where cells are actively dividing, remains underground longer when planted deeply, the plant is better protected from late spring frosts. Above-ground tissues may be frost damaged, but the plant will survive and recover as long as the growing point is not killed. Deep planting also likely reduces bird predation of seedlings, and better anchors plants against wind and washout by storm runoff.

Farmers space clumped maize plantings or "hills" roughly equidistantly, about "three to four paces" apart, consistent with the traditional spacing used in the late nineteenth century (Cushing 1974); this distance is estimated to be equivalent to about 1.5 to 2.5 m. Actual row spacing in farmers' fields averaged 1.7 m (± 0.7) (Table 4). Row spacing in nine other Zuni fields ranged from 0.8 to 2.2 m and averaged 1.4 m (Manolescu 1994).

Bean (*Phaseolus vulgaris*), watermelon (*Citrullus vulgaris*), and squash (*Cucurbita maxima*) seeds were broadcast planted at the Nutria and Bear Canyon fields. The farmers managing Bear Canyon, Nutria, and Elk fields often intercrop these additional crops with maize, as do other Zuni farmers (Manolescu 1994). Man-

agers of the Pescado field, however, stated that they do not grow watermelon and squash in their field because these crops require too much water.

Weed and pest management. Although these farmers know that weeds can compete with the crop for water and nutrients, weed management is a low priority. No apparent attempt was made to control weeds in the Pescado field. As a result, the Pescado field exhibited severe weed pressure, with pigweed (*Amaranthus* spp.), ragweed (*Ambrosia* spp.), nightshade (*Solanum* spp.), and wild sunflower (*Helianthus annuus* L.) as the common weed species present. These farmers were not concerned about the weeds, and commented that sunflowers "disguise" the maize from crows. Other Zuni farmers also believe that weeds reduce predation by crows (Manolescu 1994). At each of the other fields, occasional hoeing and hand pulling of weeds was done as time and transportation to the fields permitted. Hoeing and hand-weeding were observed in a number of other fields. As the weeds are hoed, soil was sometimes pushed up around the base of maize hills to provide additional support for crop standability against floodwaters and wind. Elk and Bear Canyon fields had minimal weeds, whereas Nutria field exhibited moderate weed pressure throughout the summer. The greater weed pressure at the Nutria field likely resulted from a greater accumulation of weed seeds over more years of cultivation and transport of weed seeds into the field by occasional cattle grazing. Weeds in the Nutria field included pigweed, ragweed, tumbleweed or Russian thistle (*Salsola kali*), and field bindweed (*Convolvulus arvensis* L.); bindweed was particularly prevalent in the lower quarter of the field where cattle more frequently graze after harvests. Maize in weedy sections of fields tended to be somewhat shorter and wilt more readily than in areas or fields having fewer weeds, indicating that weeds competed with maize for available water.

Farmers report that elk (*Cervus elaphus*) and raven (*Corvus corax,* commonly called "crows" by the Zuni) are major maize pests and difficult to control. Some attempt was made to keep elk out of the Elk field (so named because of the prevalence of elk in and around the field) by placing large logs and brush across game trails leading into the field. These measures seemed to be ineffective. Interestingly, elk did not graze on or trample maize in plots delineated by flagging tape in the Elk or other fields, whereas plants in plots outlined with string or outside the plots in the same fields were damaged by elk. Similarly, flagging tape woven through the top wire of fencing effectively reduces the incidence of elk breaking through or going over fencing in Colorado (McAndrews 2001).

Ravens are notorious for pulling up seedlings and eating grain from developing ears. Scarecrows are sometimes placed in fields in attempts to frighten away the ravens. Traditionally, these birds were trapped, killed, and hung in fields to discourage other ravens (Cushing 1974:186–187); a diagram in Cushing (1974: Plate IV) depicts a field with string strung across it and various objects hung on the strings. Although scarecrows and dead ravens were observed in other Zuni fields, these were not erected in any of the fields in this study. However, in an effort to reduce raven damage to developing ears, farmers managing the Elk field strung fishing line above the maize plants between pinyon and juniper trees and poles made from tree branches. They had observed this method at the controlled experiment fields of the larger agroecology study and decided to test it themselves. Because the method effectively deterred raven damage in their field, these

farmers indicated that they would use this approach again. Like other producers, Zuni farmers often experiment with new methods; their production systems are dynamic and evolving.

Insects, pathogens, and other animals were not mentioned by any of the farmers in this study as important pests. Farmers surveyed by Brandt (1992) and Manolescu (1994), however, complained about crop damage caused by small animals and insects, especially grasshoppers (*Melanoplus* spp.).

Plant population density. Plant population density varied widely among fields (Table 5). Measured plant population densities were within the range of densities predicted from the planting information provided by the farmers. With four kernels sown per hill and hills spaced roughly 1.5 to 2.5 m apart equidistantly, a population density of 6,400 to 18,000 plants/ha was expected at the Nutria, Bear Canyon, and Elk fields; actual mean density in these fields was 11,973 plants/ha.

Plant population density is a function of the number of kernels planted per hill, germination and emergence success, and hills per unit land area. The higher population density of the Nutria field resulted from its greater number of hills per plot, 60% greater than in the other fields, and nearly double the mean number of plants per plot of the four fields. Poor seedbed quality, together with the fewer kernels sown per hill, likely account for the relatively sparse population density of the Pescado field; good seed-soil contact is essential for seed uptake of soil moisture for germination.

Plant density among plots within each field was also highly variable, indicating uneven hill and/or kernel distribution, and/or variable germination and stand establishment success. The difference between the planted population and actual stand suggests that emergence among the four fields was about 50%, similar to the emergence success (53%) of Zuni maize observed in the controlled experiment fields (Muenchrath, unpublished data). Lack of moisture, cool soil temperature, poor seed quality, and soil mechanical resistance can impede germination and emergence. Although the plant stand is also sometimes reduced by predation of seedlings, farmers in this study did not comment on any early-season predation and expressed general satisfaction with their stands at mid-summer.

Harvest. Farmers reported that harvest normally occurs in late September or early October, depending on crop maturity, frost, and time, labor and transportation availability. Mature ears and those judged sufficiently mature by the farmers, at least at the milk stage (or approximately R3 in the staging system of Ritchie et al. 1997) were hand harvested. Farmers indicated that immature ears and plant stubble would be used as winter livestock fodder.

Grain Yield.—Grain yield varied among fields, averaging 572.4 kg/ha (± 180.7) (Table 6). Pescado field produced no harvestable grain. Its rough seedbed, poor crop stand, severe weed competition, and predation by elk resulted in few maize plants and no grain by the end of the season. Grain yield across the other three fields averaged 763.2 kg/ha (± 200.3), similar to the 750 kg/ha reported as the common yield produced in Zuni fields in the late nineteenth century (Scott 1893). Nine Zuni fields sampled in 1992 produced a mean yield of 561.2 kg/ha (± 105.7); yield of the six rainfed and runoff fields in that sample averaged 625.7 kg/ha (± 142.5) (Manolescu 1994).

TABLE 6.—Grain yield per plot, per plant, and per hectare, and number of harvestable ears per plant. Standard error of the mean reflects variability among plots within the field. Plots in the Pescado field produced no grain.

	Grain yield per plot (g/plot)		Calculated grain yield per plant (g/plant)		Estimated field grain yield (kg/ha)		Ears per plant	
Field name	Mean	± SE	Mean	± SE	Mean	± SE	Mean	± SE
Bear Canyon	631	199	38.0	10.5	252.2	79.5	1.4	0.4
Nutria	490	56	14.3	2.9	196.1	22.2	0.7	0.1
Elk	4,603	1,407	214.4	64.9	1,841.2	562.7	2.5	0.3
Pescado	0	0	0.0	0.0	0.0	0.0	0.0	0.0
Across Fields:	1,430	452	66.7	21.0	572.4	180.7	1.1	0.2

Other traditional maize grown in the region produce comparable yields. Mean yield of the four Zuni farmers' fields nearly matches the best yield (585.4 kg/ha) of 35 Hopi fields sampled in 1994, a year that was 36 to 57% drier than normal at Hopi (Manolescu 1995); the Hopi fields produced mean yield of 194.3 kg/ha (± 25.9). Current production practices of Hopi and Zuni farmers are similar. Tohono O'odham "60 day" maize grown under a range of moisture regimes in central New Mexico produced mean grain yields of 2140 (± 300) kg/ha in 1992 and 510 (± 160) kg/ha in 1993 (Muenchrath 1995); Tohono O'odham maize is customarily produced in runoff systems on the Papago Indian Reservation, located west of Tucson, Arizona in the Sonoran Desert.

Mean yield of the three productive Zuni fields is also comparable to, and the yield of the Elk field (1841 kg/ha) exceeds, the general productivity of unimproved open-pollinated cultivars. Before the early 1930s and widespread adoption of hybrids produced from improved inbred lines, national U.S. maize yield averaged about 1300 kg/ha (Hallauer et al. 1988; Troyer 1999). For comparison, modern maize hybrids produced commercially in dryland systems of the U.S. Southern Great Plains typically yield 3000 to 4000 kg/ha (Jackson et al. 1983), whereas maize grown in the more humid U.S. Corn Belt (Indiana, Illinois, Iowa, Minnesota, and Nebraska) yields about 8200 kg/ha (calculated from NASS-USDA data, 1990–2000). Commercial production systems commonly use high plant population densities, about 50,000 plants/ha, fertilizer amendments, and pesticides.

Yield differences among farmers' fields reflect differences in conditions. Killing frost before maturity limited yield in the Bear Canyon field; this field was not planted until June 1. Competition among plants, resulting from the relatively high plant population density and moderate weed pressure, likely restricted the yield of the Nutria field. Despite similar inattention, Elk field had few weeds and produced the most grain. The greater productivity of Elk field is attributed to its minimal weed competition, timely planting, multiple and timely runoff events, and short field cropping history. Unlike the other fields in this study, Elk field has no evidence of cultivation prior to 1997; lack of previous cultivation may account for the minimal weed pressure and, with the exception of elk, no other apparent pests. Fields that produce the same crop repeatedly often build up detrimental pest populations. Crop rotations and extended fallow periods can diminish or eliminate such pest problems. Manolescu (1994) noted similar trends

between yield and population density, weed pressure, planting date, and fallow period.

Similar to the relatively high yielding Elk field, the experimental fields had minimal weed pressure and were planted in mid-May. Elk field, however, produced 45% more grain relative to those experimental areas that received runoff plus its sediments and organic debris[3] (1307 kg/ha in 1997 and 1288 kg/ha in 1998 at population densities of 14,222 and 12,889 plants/ha, respectively) (Muenchrath, unpublished data). These yield differences may be due to the amount and timing of the runoff events in the respective fields. In the experimental fields, runoff was applied from three runoff events, all occurring in late July and early August 1997, and from a single event in early August 1998. Elk field had three documented runoff events: in early July, late July, and early August. The Elk field runoff events were ideally timed, shortly preceding and coinciding with the sensitive flowering stage; the four week period bracketing silk emergence is the most critical time in the determination of grain yield (Denmead and Shaw 1960; Shaw 1988). The coarser surface soil texture of Elk field may be a contributing factor, facilitating water infiltration and retention. The high grain yield of Elk field was comparable to the 1998 mean yield across all treatments at the experimental fields, 1886 kg/ha (Muenchrath, unpublished data).

The high yield of Elk field, however, is less than the full yield potential of Zuni maize. Elk field produced less than half of the best yield obtained in the controlled experiment fields, 3829 kg/ha, which was produced in 1997 with synthetic fertilizers and applications of irrigation water as needed (Muenchrath, unpublished data). The higher yield of this treatment is attributable to additional water from the greater rainfall (191 mm) and irrigation, rather than to nutrient inputs. Although leaf P at flowering was greater in this fertilized treatment, grain P and leaf and grain N contents did not differ among treatments. Prior to 1997, one of the experimental fields had been fallow for five to seven years, and the other, where the highest yield was obtained, had been fallow for at least 50 years. Fallowing, as noted by Zuni farmers, is important to maintain field productivity.

Within each of the farmers' fields, grain yield among plots varied widely. The coefficient of variation for yield among plots within a field averaged 77.4% in the three productive farmers' fields (CV range among fields was 35.8 to 99.7%). Coefficients of variation among plots in the three experimental field-years ranged from 27.2 to 75.0% (Muenchrath, unpublished data). High variability within and among fields appears to be the norm. No clear relationships between yield and cultivar type, or between yield and soil properties were observed in the farmers' fields.

Although number of ears per plant is a component of yield, grain yield per plot was only weakly correlated with number of ears per plot ($r = 0.60$ across all four fields, and $r = 0.56$ across the three productive fields), indicating that many harvested ears were partially barren. Mean number of ears/plant, 1.1 ($\pm$ 0.2), was less than that obtained in the experimental fields, 2.1 ears/plant (Muenchrath, unpublished data). The high number of ears per plant in the Elk field, together with its moderate grain yield per ear, resulted in high yields with a modest plant population density. The relatively high density and weeds in the Nutria field likely suppressed the number of ears produced per plant. The number of har-

vestable ears per plot also varied among fields and among plots within fields, averaging 33.7 ears/plot (± 3.5) or an estimated 10,120 ears/ha (± 1530) across all four of the farmers' fields (Table 6). Ear prolificacy contributes to yield stability by minimizing the likelihood of barrenness in stressful environments, and augments yield under more favorable conditions (Hallauer and Troyer 1972).

Yield reflects the compounded, cumulative effects of growth and development in response to management and the environment over the entire growing season. Grain yield derives from several components: the number of plants per unit land area, number of ears per plant, number of kernels per ear, and weight per kernel. Temperature, water, nutrient, pests, or other stresses can cause reduced emergence and plant stand, development of fewer ears or ovules, poor pollination and barrenness, and/or restricted grain fill, limiting ultimate yield. The impact of a stress depends on the prior condition of the crop and the severity, timing, and duration of the stress. Various stressors influenced the productivity of these farmers' fields.

CONCLUSIONS

While maintaining traditional elements of their agricultural strategies, Zuni farmers adapt and innovate in response to their dynamic environment. Zuni farmers continue to select field sites that are likely to have a sufficiently long growing season and receive runoff flows, exhibit desirable soil texture and native vegetation qualities, and where they have use rights. At Zuni, temperature and precipitation are highly variable from place to place, even within the same farming district, and from year to year. Although the production practices observed in this study varied somewhat among fields, management differences do not appear to be directly related to environmental differences among the fields. Nevertheless, we think that the general strategy of using geographically diverse fields would improve the chances of obtaining some successful production. The extensive production system of fields situated in many different niches likely contributed importantly to the long-term agricultural stability of Zuni and other traditional communities throughout the region.

Yield varied widely among the farmers' fields, including among the three managed by a single farmer and his family. Yield differences are attributed to differences among farmer management practices and influenced by field cropping history and seasonal environmental factors. Because moisture and nutrients were generally adequate in these farmers' fields, planting date and weed pressure likely had the greatest impact on grain yield in 1998. With average moisture and temperatures, greater yield potential could be realized in these runoff systems with timely planting and more intensive management of periodically fallowed fields. The level of management these farmers are able to expend on maize production, however, is restricted by availability of time, labor, equipment, and transportation. Despite these constraints, these and other Zuni farmers persist, largely because of the cultural value and tradition of maize and farming in Zuni life (Cleveland et al. 1995; Manolescu 1994). Challenges faced by individual Zuni and tribal efforts, such as the Zuni Sustainable Agriculture Program, to sustain agriculture as a lifeway and economic activity parallel those in other sectors of U.S. agriculture, where farmers also increasingly struggle with the competing time and resource

demands of farming and economically necessary off-farm jobs (Cleveland et al. 1995; Heller and Keoleian 2000; Hoppe et al. 2001).

To better understand the function, structure, and longevity of Zuni and other traditional runoff agricultural systems in the area, and to develop sustainable systems suitable for arid and semiarid zones, longer-term studies of a larger sample of farmers' fields and practices, continued multidisciplinary agroecological research, and agronomic evaluation of the associated cultivars are needed.

NOTES

[1] Carl S. White, Dept. of Biology, University of New Mexico, Albuquerque.

[2] Carol Brandt, New Mexico Alliance for Graduate Education & the Professoriate, Office of Graduate Studies, University of New Mexico, Albuquerque.

[3] Treatments in the controlled cropping experiment of the larger agroecology study tested the effects of different runoff components on maize productivity, specifically the effects of moisture and nutrients delivered by storm flows. Treatments were randomly assigned to plots in each field in a complete, randomized block design, with three replications in each field. The five treatments were

- Rainfed—Direct rain only;
- Runoff water—Liquid portion of runoff (water plus dissolved and suspended components) applied within 2 to 7 days of runoff event from the catchment installed above the field;
- Runoff with sediments—Liquid and solid runoff components (water, solutes, organic materials, and sediments) applied to match the above treatment application volume and timing;
- Irrigation water—Irrigation water from local reservoirs applied to match runoff application volume and timing; and
- Irrigation water with fertilizer—Irrigation water plus synthetic N and P applied as needed by the crop to avoid water-deficit stress. First application contained 101 kg N/ha and 36 kg P/ha and the next application added 77 kg N/ha, for total seasonal fertilizer application of 178, 36, and 0 kg/ha N, P, and K, respectively; K was not limiting.

Locally produced Zuni blue maize seed was soaked overnight before planting, and hand planted 13–15 May 1998 at 15 cm depth in clusters of four kernels each, spaced equidistantly 1.5 m apart. Frequent hoeing controlled weeds. Fencing kept elk and other pests out of the fields. Fishing line strung in a grid across the top of the field protected the crop from bird predation.

ACKNOWLEDGMENTS

The cooperation and gracious generosity of Wilmer Quandelacy and his family, and Stanley Sanchez and Carmichael Laiwakete are gratefully acknowledged. The assistance of the Zuni Sustainable Agriculture and Conservation Projects, and members of the agroecology research team were essential to this project. Carl White and Chris Thomas, University of New Mexico, provided precipitation, temperature, and nitrogen mineralization data. Jennifer Nelson and Jamie Patton, Iowa State University Pedometrics Laboratory, assisted with particle-size analyses. The comments and suggestions of Carol Brandt and

Kathleen Manolescu, who kindly reviewed an early draft of the manuscript, are greatly appreciated.

This material is based upon work supported by the National Science Foundation under Grant No. 9528458. Journal Paper No. J-19205 of the Iowa Agriculture and Home Economics Experiment Station, Ames, Iowa, Project No. 3666, and supported by Hatch Act and State of Iowa.

REFERENCES CITED

Abdul-Jabbar, A.S., J.W. Sammis, D.G. Lugg, C.E. Kallsen, and D. Smeal. 1983. Water use by alfalfa, maize, and barley as influenced by available soil water. *Agricultural Water Management* 6:351–363.

Anaya Garduño, Manuel. 1992. Captación de lluvia en zonas áridas y semiáridas. Ingenieria Agronómica, Colegio de Ingenieros Agrónomos de México. Noviembre-Diciembre:23–31.

Balling, Jr., Robert C. and Stephen G. Wells. 1990. Historical rainfall patterns and arroyo activity within the Zuni River drainage basin, New Mexico. *Annals of the Association of American Geographers* 80(4):603–617.

Biggar, H. Howard. 1918. The old and new in corn culture. *Yearbook of the Department of Agriculture* No. 776. U.S. Government Printing Office, Washington D.C.

Bohrer, Vorsila L. 1960. Zuni agriculture. *El Palacio* 67:181–202.

Bradfield, Maitland. 1971. *The Changing Pattern of Hopi Agriculture.* Occasional Paper 30, Royal Anthropological Institute of Great Britain and Ireland, London.

Brady, Nyle C. and Ray R. Weil. 2002. *The Nature and Properties of Soils,* 13th ed. Prentice-Hall, Upper Saddle River, New Jersey.

Brandt, Carol B. 1992. *Sustaining Traditional Crops of the Zuni Pueblo Indians of West-central New Mexico: A Harvest for the Local and Global Agricultural Community.* Ethnobiological Technical Series Paper No. 92-8. Zuni Heritage and Historic Preservation Office, Zuni, New Mexico.

———. 1995. Traditional agriculture on the Zuni Indian Reservation in the recent historic period. In *Soil, Water, Biology, and Belief in Prehistoric and Traditional Southwestern Agriculture,* ed. H. Wolcott Toll, pp. 291–301. Special Publication No. 2, New Mexico Archaeological Council, Albuquerque.

Bruins, H.J., M. Evenari, and U. Nessler. 1986. Rainwater-harvesting agriculture for food production in arid zones: the challenge of the African famine. *Applied Geography* 6:13–32.

Bryan, K. 1929. Flood-water farming. *The Geographical Review* 19:444–456.

Castetter, Edward F. and Willis H. Bell. 1942. *Pima and Papago Indian Agriculture.* University of New Mexico Press, Albuquerque.

Cihacek, Larry, Charles Glover, Estaban Herrara, and Fred Widmoyer. 1992. *Guide A-122: Soil Test Interpretations.* New Mexico State University, Las Cruces.

Cleveland, David A., Fred Bowannie, Jr., Donald F. Eriacho, Andrew Laahty, and Eric Perramond. 1995. Zuni farming and United States government policy: the politics of biological and cultural diversity in agriculture. *Agriculture and Human Values* 12(3):2–18.

Collins, G.N. 1914. A drought-resisting adaptation in seedlings of Hopi maize. *Journal of Agricultural Research* 1(4):293–306.

Critchley, Will and Klaus Siegert. 1991. Water harvesting: a manual for the design and construction of water harvesting schemes for plant production(AGL/MISC/17/91) [Online]. Available at http:www.fao.org/docrep/U3160E/u3160e00.htm (verified 13 November 2001).

Cushing, Frank Hamilton. 1974. *Zuni Breadstuff.* Originally published 1920. Indian Notes and Monographs, vol. 2. Museum of the American Indian, Heye Foundation, New York.

Damp, J.E., S.A. Hall, and S. Smith. 2002. Early irrigation on the Colorado Plateau near Zuni Pueblo, New Mexico. *American Antiquity,* in press.

Denmead, O.T. and R.H. Shaw. 1960. The

effects of soil moisture stress at different stages of growth on the development and yield of corn. *Agronomy Journal* 52:272–274.

Doerge, T.A. 1985. *A Summary of Soil Test Information for Arizona's Surface Agricultural Soils: 1965–1984.* Department of Soil and Water Science, University of Arizona, Tucson.

Doolittle, William. 2000. *Cultivated Landscapes of North America.* Oxford University Press, New York.

FAO (Food and Agriculture Organization of the United Nations). 2000. Crops and drops: making the best use of land and water [Online]. Available at ftp://ftp.fao.org/agl/aglw/docs/cropdrop.pdf (verified 13 November 2001).

Ferguson, T.J. 1985. Patterns of land use and environmental change on the Zuni Indian Reservation, 1846–1985: ethnohistorical and archaeological evidence. Plaintiff's Exhibit 6000. Expert testimony submitted to the United States Claims Court as evidence in the case of Zuni Indian Tribe v. United States, Docket 327-81L. September 30, 1985.

———. 1996. *Historic Zuni Architecture and Society.* University of Arizona Press, Tucson.

Ferguson, T.J. and E. Richard Hart. 1985. *A Zuni Atlas.* University of Oklahoma Press, Norman.

Ford, Richard I. 1985. Zuni land use and damage to Trust land, Plaintiff's Exhibit 7000. Expert testimony submitted to the United States Claims Court as evidence in the of case Zuni Indian Tribe v. United States, Docket 327-81L. 15 August 1985.

Gleick, Peter H. 2000. Water: the potential consequences of climate variability and change for the water resources of the United States [Online]. Available at http://www.gcrio.org/NationalAssessment/water/water.pdf (verified 13 November 2001).

Graham, Martha. 1990. Report on documented twentieth century irrigated agricultural fields on the Zuni Indian Reservation. Submitted to the Institute for the North American West, Seattle WA. Manuscript on file, Zuni Heritage and Historic Preservation Office, Zuni, New Mexico.

Hack, J.T. 1942. *The Changing Physical Environment of the Hopi Indians of Arizona.* Harvard University Press, Cambridge, Massachusetts.

Hallauer, A.R., Wilbert A. Russell, and K.R. Lamkey. 1988. Corn breeding. In *Corn and Corn Improvement,* 3rd ed., eds. G.F. Sprague and J.W. Dudley, pp. 463–564. Agronomy Monograph 18, American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, Wisconsin.

Hallauer, A.R. and A.F. Troyer. 1972. Prolific corn hybrids and minimizing risk of stress. In *Proceedings of the 27th Annual Corn and Sorghum Research Conference, Chicago, IL, 12–14 December,* pp. 140–158. American Seed Trade Association, Washington D.C.

Hammond, G.P. and A. Rey, eds. 1940. *Narratives of the Coronado Expedition.* University of New Mexico Press, Albuquerque.

Hart, E. Richard, ed. 1995. *Zuni and the Courts: A Struggle for Sovereign Land Rights.* University Press of Kansas, Lawrence.

Havener, Celeste Illgner. 1999. The Influence of Zuni Runoff Agriculture on Microbial Populations in Cultivated Fields. M.S. Thesis (Renewable Resources), University of Wyoming, Laramie.

Havener, C.I., J.B. Norton, and S.E. Williams. 1999. Nutrient contribution to Zuni runoff agricultural fields of watershed vegetation and soils. In *1999 Agronomy Abstracts,* p. 44. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison Wisconsin.

Heller, Martin C. and Gregory A. Keoleian. 2000. Life cycle-based sustainability indicators for assessment of the U.S. food system. Report No. CSS00–04, Center for Sustainable Systems, University of Michigan, Ann Arbor [Online]. Available at: http://css.snre.umich.edu/css_doc/CSS_2000_4.pdf (verified 7 November 2001).

Homburg, Jeffrey Allan. 2000. Anthropogenic Influences on American Indian Agricultural Soils of the Southwestern United States. Ph.D. Dissertation (Agronomy), Iowa State University, Ames (Dissertation Abstracts International No. DAI-B 61/02).

Hoppe, Robert A., James Johnson, Janet E.

Perry, Penni Korb, Judith E. Sommer, James T. Ryan, Roger C. Green, Ron Durst, and James Monke. 2001. Structural and Financial Characteristics of U.S. Farms: 2001 Family Farm Report. USDA-ERS Agriculture Information Bulletin No. 768 [Online]. Available at: http://www.ers.usda.gov/Publications/aib768/ (verified 7 November 2001).

Jackson, T.L., A.D. Halvorson, and B.B. Tucker. 1983. Soil fertility in dryland agriculture. In *Dryland Agriculture,* eds. H.E. Dregene and W.O. Willis, pp. 297–332. Agronomy Monograph 23, American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, Wisconsin.

Khalil, Samina, Thomas E. Loynachan, and M. Ali Tabatabai. 1994. Mycorrhizal dependency and nutrient uptake by improved and unimproved corn and soybean cultivars. *Agronomy Journal* 86: 949–958.

Kintigh, K.W. 1985. *Settlement, Subsistence, and Society in Late Zuni Prehistory.* Anthropological Papers of the University of Arizona, no. 44. University of Arizona Press, Tucson.

Klemmedson, J.O. 1989. Soil organic matter in arid and semiarid ecosystems: sources, accumulation, and distribution. *Arid Soil Research and Rehabilitation* 3:99–114.

Klute, A., ed. 1986. *Methods of Soil Analysis. Physical and Mineralogical Methods,* 2nd ed. Monograph 9, part 1. American Society of Agronomy and Soil Science Society of America, Madison, Wisconsin.

Ludwig, J.A. 1987. Primary productivity in arid lands: myths and realities. *Journal of Arid Environments* 13:1–7.

McAndrews, Gina M. 2001. Evaluation of a Participatory Approach to Mediate Conflict between Wildlife and Livestock Interests. Ph.D. Dissertation (Agronomy), Iowa State University, Ames.

Manolescu, Kathleen. 1994. The culture of Zuni land technologies: an appendix for the Zuni Development Plan, Pueblo of Zuni and Zuni Conservation Project. Report on file, Zuni Conservation Program, Blackrock, New Mexico

———. 1995. Hopi corn production. A report on research conducted for the Bureau of Indian Affairs. Report on file, Bureau of Indian Affairs, Phoenix area office, Phoenix, Arizona.

Maxwell, Timothy D. 2000. Looking for Adaptation: A Comparative and Engineering Analysis of Prehistoric Agricultural Technologies and Techniques in the Southwest. Ph.D. Dissertation (Anthropology), University of New Mexico, Albuquerque.

Metting, B. 1991. Biological surface features of semiarid lands and deserts. In *Semiarid Lands and Deserts: Soil Resource and Reclamation,* ed. J. Skujins, pp. 257–293. Marcel Dekker, New York.

Muenchrath, Deborah Ann. 1995. Productivity, Morphology, Phenology, and Physiology of a Desert-adapted Native American Maize (*Zea mays* L.) Cultivar. Ph.D. Dissertation (Agronomy), Iowa State University, Ames (Dissertation Abstract No. 95–40927).

Nabhan, Gary P. 1984. Soil fertility renewal and water harvesting in Sonoran Desert agriculture: the Papago example. *Arid Lands Newsletter* 20:21–28.

Norton, Jay B. 1996. Soil, Geomorphic, and Ecological Factors in Zuni Runoff Agriculture. M.S. Thesis (Agronomy), Iowa State University, Ames.

———. 2000. Agroecology, Hydrology, and Conservation of Ephemeral Streams and Alluvial Fans, Zuni Pueblo, New Mexico. Ph.D. Dissertation (Forestry), University of Montana, Missoula.

Norton, J.B. and A.H. Laahty. 1999. Traditional Zuni landscape stability and soil fertility renewal. In *1999 Agronomy Abstracts,* p. 44. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, Wisconsin.

Norton, J.B., R.R. Pawluk, and J.A. Sandor. 1998. Observation and experience linking science and indigenous knowledge at Zuni, New Mexico. *Journal of Arid Environments* 39:331–340.

Olson, R.A. and D.H. Sander. 1988. Corn production. In *Corn and Corn Improvement,* 3rd ed., eds. G.F. Sprague and J.W. Dudley, pp. 639–686. Agronomy Monograph 18, American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, Wisconsin.

Orr, B.R. 1987. *Water Resources of the Zuni Tribal Lands, McKinley and Cibola Counties, New Mexico.* U.S. Geological Survey, Denver, Colorado.

Osborn, H.B. and K.G. Renard. 1970. Thunderstorm runoff on the Walnut Gulch Experimental Watershed, Arizona, USA. *International Association of Scientific Hydrology* 96:455–464.

OTA (Office of Technology Assessment). 1983. *Water-related Technologies for Sustainable Agriculture in U.S. Arid/Semiarid Lands.* U.S. Congress, Office of Technology Assessment Document F-212, Oct. 1983. Washington D.C.

Page A.L., R.H. Miller, and D.R. Keeney, eds. 1982. *Methods of Soil Analysis. Chemical and Microbiological Properties,* 2nd ed. Monograph no. 9, part 2. American Society of Agronomy and Soil Science Society of America, Madison, Wisconsin.

Pawluk, Roman R. 1995. Indigenous Knowledge of Soil and Agriculture at Zuni Pueblo, New Mexico. M.S. and M.A. Thesis (Agronomy and Anthropology), Iowa State University, Ames.

Prevost, D.J., R.L. Ahrens, and D.M. Kriz. 1984. Traditional Hopi agricultural methods. *Journal of Soil and Water Conservation* 39:170–171.

Prevost, D.J., Fred Bowannie, Jr., and Andrew Laahty. 1993. Soils in Zuni rainfall runoff fields. *Zuni Farming for Today and Tomorrow* 2 (Summer):8–9. (Occasional newsletter of the Zuni Sustainable Agriculture Project and the Zuni Folk Varieties Project, Zuni NM).

Rhoads, F.M. and J.M. Bennett. 1990. Corn. In *Irrigation of Agricultural Crops,* eds. B.A. Stewart and D.R. Nielsen, pp. 569–596. Agronomy Monograph 30, American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, Wisconsin.

Rhoads, F.M. and C.D. Yonts. 1984. Irrigation Scheduling for Corn—Why and How [Online]. National Corn Handbook, Publication NCH-20. Purdue University Cooperative Extension Service. Available at http://www.agcom.purdue.edu/AgCom/Pubs/NCH/NCH-20.html (verified 13 November 2001).

Rhode, David. 1990. Agriculture and water use before the Twentieth Century on the Zuni Reservation, west-central New Mexico. Submitted to the Institute for the North American West, Seattle WA. Manuscript on file, Zuni Heritage and Historic Preservation Office, Zuni NM.

———. 1995. Estimating agricultural carrying capacity in the Zuni region, west-central New Mexico: a water allocation model. In *Soil, Water, Biology, and Belief in Prehistoric and Traditional Southwestern Agriculture,* ed. H. Wolcott Toll, pp. 85–100. Special Publication No. 2, New Mexico Archaeological Council, Albuquerque.

Ritchie, Steven W., John J. Hanway, and Garren O. Benson. 1997. How a Corn Plant Develops. Special Report No. 48. Iowa State University Cooperative Extension Service, Ames.

Sandor, Jonathan A. 1995. Searching soil for clues about Southwest prehistoric agriculture. In *Soil, Water, Biology, and Belief in Prehistoric and Traditional Southwestern Agriculture,* ed. H. Wolcott Toll, pp. 119–137. Special Publication No. 2, New Mexico Archaeological Council, Albuquerque.

Sandor, Jonathan A. and P.L. Gersper. 1988. Evaluation of soil fertility in some prehistoric agricultural terraces in New Mexico. *Agronomy Journal* 80:846–850.

Sandor, J.A., J.B. Norton, D.A. Muenchrath, C.S. White, S.E. Williams, M.D. Ankeny, C.I. Havener, J.A. Homburg, P.D. Stahl, and C.J. Thomas. 1999. Soil, crop, and ecosystem studies of Native American runoff agriculture. In *1999 Agronomy Abstracts,* p. 38. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, Wisconsin.

Scott, Julian. 1893. Pueblos of Laguna, Acoma, and Zuni. In *Extra Census Bulletin: Moqui Pueblo Indians of Arizona and Pueblo Indians of New Mexico, Eleventh Census of the United States,* eds. Thomas Donaldson, expert special agent, and Robert P. Porter, superintendent, pp. 121–131. United States Census Printing Office, Washington D.C.

Shaw, Robert H. 1988. Climate requirement. In *Corn and Corn Improvement,* 3rd ed., eds. G.F. Sprague and J.W. Dudley, pp. 609–638. Agronomy Monograph 18, American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, Wisconsin.

Shreve, F. 1934. Rainfall, runoff, and soil moisture under desert conditions. *An-*

nals of the Association of American Geographers 24(3):131–156.

Sitgreaves, L. 1853. Report of expedition down the Zuni and Colorado Rivers in 1851. Executive Document 59, 32nd Congress, 2nd Session. Washington D.C.

Soil Survey Staff. 1993. *Soil Survey Manual,* USDA Handbook 18, 2nd ed. U.S. Government Printing Office, Washington D.C.

———. 1999. Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys, USDA Agricultural Handbook 436, 2nd edition [Online]. Available at http://www.statlab.iastate.edu/soils/nssc/ (verified 4 October 2001).

Troyer, A. Forrest. 1999. Background of U.S. hybrid corn. *Crop Science* 39:601–626.

Tuan, Yi-Fu, Cyril E. Everard, Jerold G. Widdison, and Iven Bennett. 1973. *The Climate of New Mexico,* rev. ed. State Planning Office, Santa Fe, New Mexico.

USDA-NRCS, pending. *Soil Survey of McKinley County, New Mexico.* U.S. Government Printing Office, Washington D.C.

Van West, Carla R. 1996. Chapter 17. The heuristic value of estimates of prehistoric agricultural production: a case study from southwestern Colorado. In *Interpreting Southwestern Diversity: Underlying Principles and Overarching Patterns,* eds. Paul R. Fish and J. Jefferson Reid, pp. 133–145. Anthropological Research Papers no. 48, Arizona State University, Tempe.

Waters, M. R. 1992. *Principles of Geoarchaeology: A North American Perspective.* University of Arizona Press, Tucson.

West, N. E. 1991. Nutrient cycling in soils of semiarid and arid regions. In *Semiarid Lands and Deserts: Soil Resource and Reclamation,* ed. J. Skujins, pp. 295–332. Mercel Dekker, New York.

White, C.S., and C.J. Thomas. 1999. Nitrogen contributions from precipitation to a corn field at Zuni, New Mexico. In *1999 Agronomy Abstracts,* p. 40. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, Wisconsin.

Will, George F. and George E. Hyde. 1917. *Corn Among the Indians of the Upper Missouri.* Originally published 1910. University of Nebraska Press, Lincoln.

Wilson, Gilbert L. 1987. *Buffalo Bird Woman's Garden: Agriculture of the Hidatsa Indians.* Minnesota Historical Society Press, St. Paul.

Worster, D. 1985. *Rivers of Empire: Water, Aridity, and the Growth of the American West.* Pantheon Books/Random House, New York.

Journal of Ethnobiology 22(1): 35–60 Summer 2002

VACCINIUM PROCESSING IN THE WASHINGTON CASCADES

CHERYL A. MACK and RICHARD H. McCLURE

Heritage Program, Gifford Pinchot National Forest, 2455 Highway 141, Trout Lake, WA 98650

ABSTRACT.—Among the native peoples of south-central Washington, berries of the genus *Vaccinium* hold a significant place among traditional foods. In the past, berries were collected in quantity at higher elevations in the central Cascade Mountains and processed for storage. Berries were dried along a shallow trench using indirect heat from a smoldering log. To date, archaeological investigations in the Gifford Pinchot National Forest have resulted in the identification of 274 *Vaccinium* drying features at 38 sites along the crest of the Cascades. Analyses have included archaeobotanical sampling, radiocarbon dating, and identification of related features, incorporating ethnohistoric and ethnographic studies. Archaeological excavations have been conducted at one of the sites. Recent investigations indicate a correlation between high feature densities and specific plant communities in the mountain hemlock zone. The majority of the sites date from the historic period, but evidence of prehistoric use is also indicated.

Key words: berries, *Vaccinium,* Cascade Mountains, ethnohistory, archaeobotanical record.

RESUMEN.—Entre los indígenas del centro-sur de Washington, las bayas del género *Vaccinium* occupan un lugar significativo entre los alimentos tradicionales. En el pasado, estas bayas se recogían en grandes cantidades en las zonas elevadas del centro de las Montañas de las Cascadas y se procesaban para el almacenamiento. Las bayas se secaban a lo largo de una zanja usando calor indirecto prodducido por un tronco en ascuas. Hasta la fecha, las investigaciones arqueológicas en el Bosque Nacional de Gifford Pinchot han dado como resultado la identificación de 274 restos de secado de *Vaccinium* en 38 localidades a lo largo de la cresta de las Moñtanas de las Cascadas. Los análisis han incluido el muestreo archaeobotánico, datación por radiocarbono e identificación de restos relacionadas, incorporando estudios ethnohistóricos y ethnográficos. Se han llevado a cabo excavaciones arqueológicas en una de las localidades. Investigaciones recientes indican una correlación entre altas densidades de restos y las comunidades vegetales específicas en el piso de *Tsuga mertensiana.* La mayoría de las localidades datan del período histórico, pero también se indica evidencia de uso prehistórico.

RÉSUMÉ.—Parmi les indigènes de Washington sud-central, les baies du genre *Vaccinium* tiennent une place significative parmi les nourritures traditionnelles. Dans le passé, des baies ont été cueillies en quantité à de hautes altitudes dans les montagnes centrales de Cascade et transformées en vîvres. Des baies ont été séchées le long d'un fossé peu profound en utilisant la chaleur indirecte d'une bûche brûlante sans flamme. Jusqu'ici, les investigations archéologiques dans la Forêt Nationale de Gifford Pinchot ont eu comme conséquence l'identification de 274 dispositifs de séchage de *Vaccinium* à 38 sites le long de la crête des Cascades.

Les analyses mises en oeuvre ont compris le prélèvement archéobotanique, le radiocarbone datant, et l'identification des dispositifs relatifs, incorporant des études ethnohistoriques et ethnographiques. Des excavations archéologiques ont été conduites à un des sites. Les investigations récentes indiquent une corrélation entre les densités élevées de dispositif et les communautés spécifiques de plantes dans la zone de hemlock de montagne. La majorité des sites datent de la période historique, mais l'évidence d'une utilité préhistorique est également indiquée.

Berries of the genus *Vaccinium* hold an important place among traditional foods for Indian people in the Pacific Northwest. For Yakama and Warm Springs Indians of Washington and Oregon, huckleberries are considered one of the ritually important foods, honored along with roots, venison and salmon at a series of three "first foods" ceremonies held during the gathering season. The last of these ceremonies is held at the time the berries ripen in the mountains, usually between late July and early August. In historic times, Sahaptin and Chinookan-speaking groups from the mid-Columbia River area collected and dried berries at upland locations within what is now the Gifford Pinchot National Forest. Sahaptin-speaking bands identified as Klickitat, Yakama, Skinpah, Kamiltpah, Wyam, and Tenino, along with Chinookan-speaking bands such as Wishxam, Wasco, and Watlala, all gathered berries in this area, which is situated along the crest of the Cascade mountain range between Mt. Adams and the Columbia River (Figure 1).

The following is a discussion of recent archaeological research on the process of drying huckleberries, including results of surveys, excavation, and feature sampling. A review of ethnographic source material relating to huckleberry processing is included, along with information derived from field trips and interviews with contemporary Yakama elders. Considerations of chronology and the manner in which berry processing relates to the larger issue of resource intensification in the Cascades are also discussed.

ETHNOHISTORIC SOURCES

There are numerous references in ethnographic and historic literature to huckleberry collection and processing within what is now the Gifford Pinchot National Forest, ranging from internal Forest Service documents to published ethnographic reports (Table 1). Several of these are primary sources, including Henry Brewer's description of an 1845 trip to the Mt. Adams huckleberry fields (Mudge 1854), the 1853 journal of George McClellan, the 1878 journal of Francis Marion Streamer (Briley 1986), the ethnographic reports of George Gibbs (Gibbs 1855, 1877), and C. E. Rusk's description of a trip around Mt. Adams in 1890 (Rusk 1924). Secondary sources are numerous. See Table 1 for an annotated summary.

Forest Service documents include a 1910 fire report (Stabler 1910), a 1911 report on Forest resources (Wilcox 1911), and a 1938 recreation report (Langdon 1938). As early as 1928, Forest Service photographers were documenting traditional native practices in the Sawtooth Huckleberry Fields, a large traditional berry patch still used today. Ray Filloon, who worked as a Forest Guard there in the

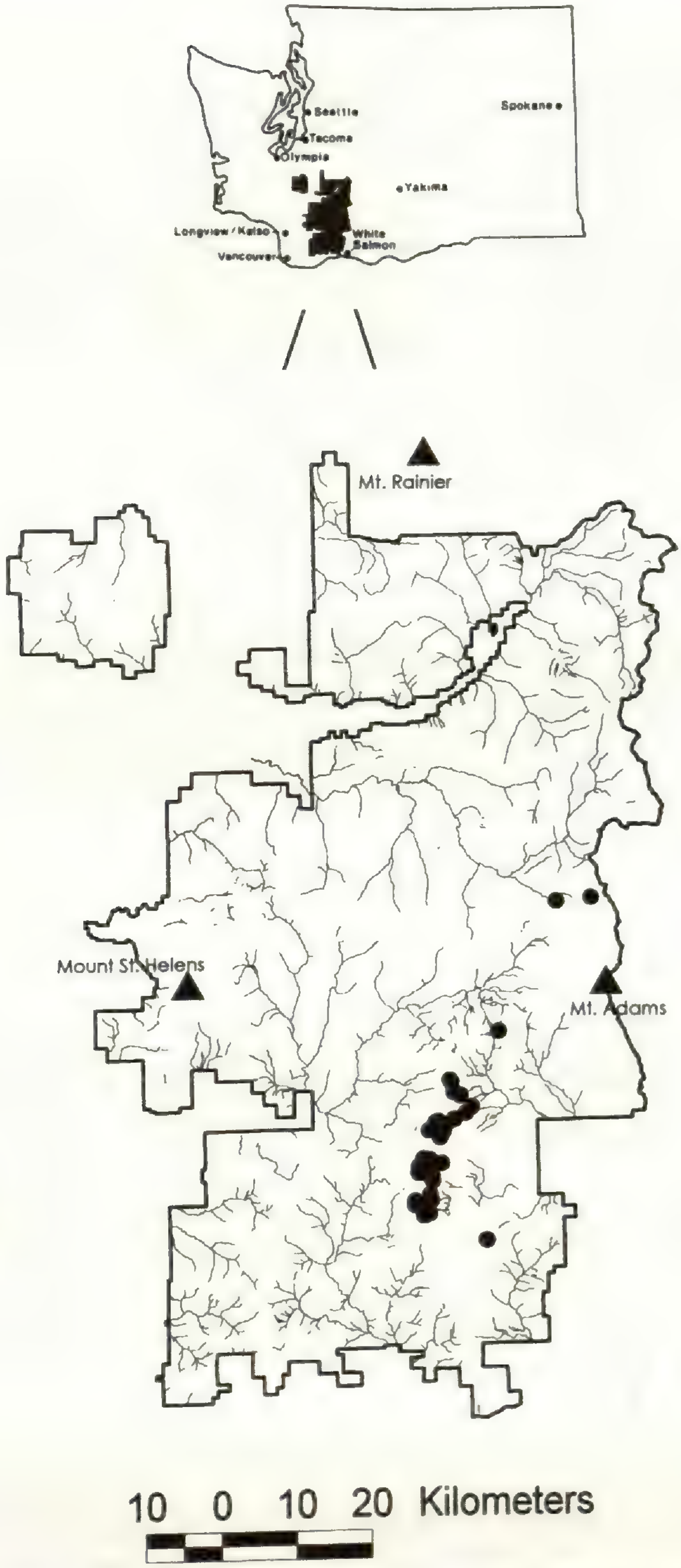


FIGURE 1.—Distribution of *Vaccinium* processing features, Gifford Pinchot National Forest, Washington.

TABLE 1.—Summary of ethnohistoric source data.

Ethnohistoric—primary observer	Date of observation	Observation
Henry Perkins—Methodist missionary (Boyd 1996)	August 19, 1843	Described length of stay at camps; quantity of dried berries collected
Henry Brewer—Methodist missionary (Mudge 1854)	September 15, 1845	Described berry camp; length of stay at camp; method of log fire drying
George B. McClellan—U.S. Army surveyor (1853)	August 1853	Described size of berry camp; associated activities (sweat lodge, wells)
George Gibbs—Ethnologist with McClellan party (1855, 1877)	August 1853	Noted huckleberries were dried and stored for winter use
Charles Olney—Yakama Indian (Hines 1992)	August 1869	Described variety in size and composition of berry camps
Francis Marion Streamer—traveled with Indians to berry fields (Briley 1986)	August 1878	Described length of stay at berry camps; size of camps; log fire drying method; quantity of berries collected
Claude E. Rusk—made circuit of Mt. Adams (1924)	1890	Described berry camp and drying of berries
Ellen Saluskin—Yakama Indian (Martin 1979)	1890s	Described method of log fire drying
Fred Plummer—USGS surveyor (1900)	1899	Noted that Indians purposefully burned to promote growth of berries
H. O. Stabler—Columbia National Forest Supervisor (1910)	1910	Noted that Indians caused fires by leaving drying log smoldering
Arthur Wilcox—Forest Assistant (1911)	1911	Noted that fires were often caused by berry drying logs
Eleanor Abraham (1963)	1920s	Described method of log fire drying
Louise Billy—Yakama Indian (1992, 1995)	1930s	Described method of log fire drying
Elsie Dick—Yakama Indian (1992, 1995)	1930s	Described method of log fire drying
Ray M. Filloon—Forest Guard, photographer (1952)	1930s	Described and photographed method of log fire drying

TABLE 1.—(continued)

Ethnohistoric—secondary source	Source of information	Information
Verne Ray (1936)	Interviews with Klickitat consultant	Listed berry camps in area
David French (1957, 1965)	Interviews with Warm Springs consultants	Described method of log fire drying
William Osborne (1953)	Ethnohistoric research	Described method of log fire drying
Mary Schlick (1994)	Interviews with Yakama consultants	Described preparing logs for use in drying
Eugene Hunn (1990)	Interviews with Warm Springs and Yakama consultants	Described camps and method of log fire drying
Norton, Boyd, and Hunn (1983)	Ethnohistoric research	Described camps and method of log fire drying
Click Relander (1959)	Interviews with Yakama consultants	Listed berry camps in area
Spier and Sapir (1930)	Interviews with Wishram consultants	Described storage of dried berries; use as item of trade
Edward Curtis (1911a, 1911b)	Interviews with Yakama, Klickitat and Chinookan consultants	Described storage of dried berries; linguistic distinction of dried and stored berries
George Murdock (1980)	Interviews with Tenino consultants	Described use of dried berries
Melville Jacobs (1934)	Interviews with Taidnapam consultant	Described drying berries
Helen Schuster (1975)	Interviews with Yakama consultants	Described method of log fire drying
Allan Smith (1964)	Interviews with Yakama, Taidnapam, Nisqually, and Muckleshoot consultants	Described alternative methods of drying berries, including log fire method

1930s, extensively photographed traditional methods of drying huckleberries, and later published his observations in an illustrated magazine article (Filloon 1952).

BERRY PICKING

Berry camps were established in and adjacent to meadows and fire-created openings in the mountains, usually near lakes or streams. Social composition and size of the camps varied, but camps typically consisted of one or more extended family groups. Published accounts range from descriptions of single family camps to large gatherings representing multiple bands (Streamer in Briley 1986; McClellan 1853; McWhorter in Hines 1992).

Several sources discuss the length of stay at huckleberry camps (Briley 1986:

61). On August 19, 1843, Methodist minister Henry Perkins wrote that the Indians at Wascopam (The Dalles) had moved to the mountains for berries:

> "They obtain at this season the large mountain huckleberry. The berry month is to the natives like one great holy-day. It always succeeds to the fishing months. . . . They are usually absent on these excursions, from four to six weeks; during which, each family lays in, for winter use, four or five pecks of nice dried berries." (Boyd 1996:275–276)

Methodist minister Henry Brewer accompanied Indians from The Dalles to the Mt. Adams fields in September of 1845. They left The Dalles on September 13. After arriving at their camp on September 15, 1845, Brewer wrote:

> "Here are a large company of Indians, busily engaged in picking whortleberries: these they dry by the fire, and preserve them for future use. They spend a month or more here, every season." (Mudge 1854:52–53)

Shelters used at these camps consisted of conical, tipi-like lodges with tule mat coverings over poles. In some cases wells were dug along the shores of lakes to provide a source of drinking water separate from that used by horses (McClellan 1853). Small sweat lodges were also erected (McClellan 1853; Briley 1986). Men often hunted deer, elk and bear while in the mountains, and sometimes traveled as far as 25 km from berry camps to obtain salmon for use in the camps. In the early 1900s there was an established trail leading from the Sawtooth Berry Fields to ***m'tuliash***, a fishing site at the Lower Falls on the Lewis River, a place where people continued to fish for salmon into the 1930s (Billy 1992). Black lichen (*Bryoria fremontii* Tuck.) was also gathered during the huckleberry season, as were whitebark pine nuts (*Pinus albicaulis* Engelm.).

Berry camps were dispersed throughout the upland berry patches, and berries were generally picked in the area surrounding the camp. However, pickers might venture as far as three kilometers from camp in search of berries, particularly on mountain slopes. Although at least four species of *Vaccinium* occur together in this area, the dark blue-black berries of *V. membranaceum* Dougl., or ***wiwnu*** in Sahaptin, were the focus of intensive harvest. Another species which was highly sought after, but which was only available at the highest elevations, was *V. deliciosum* Piper, or ***ililmuk*** in Sahaptin. The berries of *V. ovalifolium* Smith and *V. alaskaense* Howell are also common, but are less sweet and were apparently not sought after in quantity (Hunn 1990:178–179). However, women would often pick "blueberries" to mix in with huckleberries. The berries were picked and placed in coiled cedar root or folded cedar bark baskets tied around the waist (Figure 2). When full, these picking baskets were emptied into large baskets (2–5 gallons), supported by a tumpline or carrying strap across the shoulders. These large baskets were used to transport berries to camp as well as to drying locations.

THE ECONOMICS OF HUCKLEBERRIES

Historically, huckleberries were an important commodity for several reasons. For people who relied on stored foods for several months of the year, the relatively high vitamin C content of huckleberries was an important nutritional factor. A

FIGURE 2.—Yakama man picking huckleberries in the Sawtooth Berry Fields, Gifford Pinchot National Forest. August 1933 photograph by K. D. Swan, USDA Forest Service.

single cup of huckleberries provides nearly half the recommended dietary allowance (RDA) of vitamin C for an adult (Hilty 1972:16). Although the vitamin C content varies with season of harvest, storage conditions and species, it is notable that two studies found a higher vitamin C content in either stored or dried *Vaccinium* berries than in fresh (Benson et al. 1973:145; Keely 1980:42–43).

Huckleberries also functioned as an important item of trade. According to Spier and Sapir (1930:185), dried huckleberries were made into packages of standard size by the Wishram, and they attribute this standardization to a pattern of extensive trade. Francis Streamer makes reference in his 1878 journal to the fact that berries were being collected for local commerce, noting, "We have dried about 10 bushels of huckleberries and have a full supply on hand of fresh berries to sell at the Dalles" (Briley 1986:60–61). Ray Filloon, in his 1952 article "Huckleberry Pilgrimage," also describes how Indian women in the 1930s made cedar bark baskets, ". . . for transporting the berries from the patch to their homes or to towns, where they were sold house to house or traded at stores for food or other goods" (Filloon 1952:8).

A 1911 newspaper article entitled "At Indian Race Track" provides a succinct description of huckleberry economics:

> "They quickly pick their berries, take most of them to a fire-swept part of the mountain side, spread them on mats near a dead log, set it afire and with paddles stir the berries till thoroughly dried. The undried ber-

FIGURE 3.—Sun-drying huckleberries, August 1937. Photograph by Ray M. Filloon, USDA Forest Service.

ries are brought to town and sold for 50 cents to $1 per gallon." (Dunnicliff 1911)

In communities surrounding the Gifford Pinchot National Forest, huckleberries continue to function as a marketable commodity, and are sold by both Indians and non-Indians.

I-LA CIK WIWNU: DRYING THE BERRIES

Before 1935, the principal method of drying huckleberries in this area involved the use of reflected heat from a log fire. The following description of the drying process was derived partly from oral interviews conducted in 1992 and 1995 with two women who had assisted with drying huckleberries in this manner as children in the 1920s and early 1930s (Billy 1992, 1995; Dick 1992, 1995). This process has also been described by Abraham (1963), Filloon (1952), French (1965), Hunn (1990), Martin (1979), Norton et al. (1983), Osborne (1953), Schlick (1994), Schuster (1975), Stabler (1910), and Wilcox (1911).

A preliminary step in the drying process involved spreading the berries on mats in the sun for two or three days. Children were assigned the task of keeping birds and small animals away from the drying berries (Figure 3). The next step involved the selection of a suitable log, one that was sufficiently dry and decayed to maintain a smoldering fire. Trees near camp were sometimes felled for this purpose, or girdled in preparation for future use. Francis Marion Streamer de-

FIGURE 4.—Wáksaspam, a Yakama woman, drying huckleberries at Meadow Creek Indian Camp, August 1935. Photograph by Ray M. Filloon, USDA Forest Service.

scribed in his 1878 journal how he and Chief John felled a "large dry fir tree" to use as a drying log, which he said served two families (Briley 1986:59). In 1973 Wilson Charley recalled for Mary Schlick the felling of a large dead tree at Meadow Creek camp for his grandmother to use as a drying log (Schlick 1994:83). Another woman recalled how her uncle would debark standing trees at Meadow Creek camp to have them ready for future use as drying logs.[1]

After the log was selected, a trench approximately one meter wide was then excavated along one side of it, and a sloping mound of earth was built up along the edge of this trench, opposite the log. Beargrass (*Xerophyllum tenax* (Pursh.) Nutt.) was spread over the sloping face of the mound, and a tule mat laid lengthwise across it. A pole was sometimes laid across the base of the mound, and the lower edge of the tule mat was propped over the pole. Rocks were gathered and arranged in a single row along the base of the trench, preventing the mat from sliding forward. The rocks undoubtedly also served a secondary function as an aid in storing and reflecting heat. The mats might also be weighted down along the edges with rocks or poles.

Children were assigned the task of carrying water to the drying site, and of collecting the firewood needed to ignite the log. Water was needed to prevent the berries from being burned, in the event that the log burned too intensely. When all was ready, berries were spread over the mat and the log was ignited. To ensure that the berries dried evenly and did not burn, a woman would regularly stir the berries with a long, oar-like wooden paddle (Figures 4, 5). The width of the trench, approximately one meter, most likely reflected the optimal distance for the berries to be situated from the heat source. The process was usually initiated early in the day, and the berries would take six to eight hours to dry. The dried berries were

FIGURE 5.—Lena Waters Pinkham drying huckleberries, August 1937. Photograph by Ray M. Filloon, USDA Forest Service.

then packed into baskets and carried back to camp, where they might again be spread on mats in the sun to complete the drying process. When dried in this manner, berries would reportedly keep up to a year in storage. If enough of the log remained, it could be used again in subsequent years. Several consultants have stated that the drying log "belonged" to an individual, and would not be used by others.

THE ARCHAEOLOGY OF *VACCINIUM* PROCESSING

Prior to 1985, archaeological surveys on National Forest lands in the Pacific Northwest failed to recognize *Vaccinium* processing sites. Forest Service photographer Ray Filloon (1952:12–13) had, over thirty years earlier, described finding "... the all-but obliterated long ridges and trenches with rows of stones, where long ago the Indian women had dried their huckleberries. ..." In 1985 and 1986, archaeologists first documented trench features with "rows of stones" during reconnaissance in and near the Indian Heaven Wilderness, Gifford Pinchot National Forest. In following years, more sites were found through systematic archaeological surveys for wilderness trail reconstruction projects and timber sales outside the wilderness. Between 1995 and 1999, several archaeological surveys were conducted specifically to identify additional *Vaccinium* processing sites within and adjacent to the Indian Heaven Wilderness.

To date, a total of 274 *Vaccinium* processing features have been identified and documented at 38 sites within the Gifford Pinchot National Forest (Table 2). Most of the sites are located in or adjacent to the Indian Heaven Wilderness, along the crest of the Cascade Mountain Range between Mt. Adams and the Columbia River. Two sites occur in the upper Cispus River watershed, near the north side

FIGURE 6.—Berry processing paddle (*su-xaash*) from Meadow Creek Trail site (45SA424). Photograph by Cheryl A. Mack, USDA Forest Service, 1998.

of Mt. Adams. At least one site with similar features has been identified further north, within the Mt. Baker-Snoqualmie National Forest (Miss and Nelson 1995). All of these sites are characterized by the presence of linear drying trench features, visible on the surface. Criteria for identification include:

1. Trench—dimensions averaging 1 m in width, 6 m in length; and 20 cm in depth
2. A row of rocks, rarely fire-cracked, along base of trench (exposed or sub-surface)
3. Mound of soil parallel and adjacent to one side of the trench
4. Charcoal, usually in thin but dense layer along base of trench
5. Remains of log, charred or decayed, parallel to trench, opposite mound of soil

Although all features were detectable on the surface, probing with a trowel or tile probe was necessary to identify subsurface rocks and charcoal. Agnes Mark, Louise Billy, and Elsie Dick, Yakama elders personally familiar with their construction and use, confirmed functional identification of the trenches as *Vaccinium* processing features in the field.

The sites range in size from Big Meadow Camp (45SA338) at 96.3 ha with 65 features, to several sites represented by single trench features. Feature density within Big Meadow Camp averages 1 trench per 1.45 ha area, reflecting both the highly dispersed nature of features within sites, and the difficulty of defining site

boundaries. In addition to the trenches, a number of the sites also contain features associated with residential use. Surface artifacts associated with residential occupancy, berry collection and processing were also identified at many sites.

ASSOCIATED ARCHAEOLOGICAL FEATURES AND ARTIFACTS

Several of these sites contain a complex of associated features that demonstrate their function as residential camps. These features include tipi rings, sweat lodge remains, a roasting pit, culturally modified trees, cut stumps, wells, refuse dumps and other associated artifacts. Cached tipi poles were noted at one site, and linear horse race tracks were documented at two other sites. Refer to Table 2 for a summary of features and artifacts at each site.

In 1998, a carved wooden paddle (Figure 6) was recovered from the surface at site 45SA424. The weathered paddle, made of cedar, measures 2.76 m in length, with a 3-cm diameter shaft or handle. The paddle blade is 50 cm long and 7.5 cm wide. The proximal end tapers to a dull point, and is burned. Tribal representatives visited the site and identified the artifact as a ***su-xaash***, or berry processing paddle. The specimen from site 45SA424 is virtually identical to that used by Lena Waters in a 1935 Filloon photograph (Figure 5). The paddle was associated with a cluster of other artifacts, including a galvanized bucket and a white enamelware pot. These items had likely been cached in the limbs of an adjacent tree.

ENVIRONMENTAL CHARACTERISTICS

Distinct patterning is evident in the distribution of berry processing sites, both in terms of elevation and association with specific plant communities. Site elevations range from about 940 to 1550 meters. The majority of the 38 sites (76%) occur in the mountain hemlock vegetation zone, with a few (8%) found in the subalpine fir zone. A small number (16%), from lower elevations, lie within the Pacific silver fir zone.

We found that most of the berry processing features are closely associated with a single plant community. Seventy percent occur within a mountain hemlock/red heather-delicious blueberry (TSME/PHEM-VADE) association (Diaz et al. 1996). This plant community typically occupies high elevation parkland areas in the mountain hemlock zone, often as a mosaic of meadow and tree islands (Figure 7). Topography is generally flat to moderately sloping, including upland benches and areas adjacent to small lakes, ponds, or wet meadows. Both *Vaccinium deliciosum* and *V. membranaceum* are common within this plant community.

Berry processing sites at lower elevations are primarily associated with seral plant communities in Pacific silver fir forests, where *V. membranaceum* is common but *V. deliciosum* does not occur. Berry patches within this zone are transitional in nature, and succession can be quite rapid, ultimately reducing huckleberry productivity. In the mountain hemlock zone, where subalpine plant communities exhibit relative stability of species composition, berry patches may remain productive over a greater time span.

Indians in this area used fire as a tool to enhance huckleberry productivity, particularly at lower elevations. Plummer (1900), in an early report for the United

TABLE 2.—Inventory of *Vaccinium* processing sites in Gifford Pinchot National Forest.

State no.	Name	Elevation	Plant association	Number of processing features	Associated features and artifacts
45SA207	Tipi Pole Camp	1213 m	ABAM/VAME-XETE	8	tipi rings, sweat lodge, dump, trail, CMTs
45SA262	*SkIs-xaLia* (Little Huck Camp)	938 m	ABAM/VAME-XETE	8	tipi rings, tipi poles, CMTs
45SA263	Heart Lake	1402–1463 m	TSME/PHEM-VADE	16	trail
45SA265	*Kpss-wa-nite*	1182–1207 m	TSME/VAME-XETE	5	sweat lodge, lithics, CMTs
45SA289	Green Lake South	1305 m	TSME/PHEM-VADE	1	trail
45SA290	Red Mountain	1292 m	TSME/PHEM-VADE	2	none
45SA291	*Kalama't* (Racetrack)	1305 m	ABLA/XETE	3	tipi rings, sweat lodges, well, CMTs, artifacts
45SA292	Green Lake	1295 m	ABLA/XETE	23	tipi rings, sweat lodge, CMTs
45SA293	Berry Mountain	1305 m	TSME/PHEM-VADE	5	Racetrack Trail
45SA294	Indian Heaven Trail	1463 m	TSME/RHAL	4	trail
45SA295	Deep Lake	1548 m	TSME/RHAL	2	trail
45SA336	Naha Lake Camp	1451 m	TSME/PHEM-VADE	4	trail
45SA338	Big Meadow camp	1463 m	TSME/PHEM-VADE	65	tipi rings, sweat lodges, well, trail
45SA360	Hidden Lakes	1183 m	ABAM	2	old trail
45SA364	*IskIs Watum* (Surprise Lakes #1)	1295 m	TSME	1	well, dump
45SA365	Surprise Lakes #2	1295 m	TSME	3	wells, hearth
45SA375	Surprise Lakes #7	1295 m	TSME	2	none
45SA412	Tepee Camp	1231 m	TSME/VAME	11	sweat lodge
45SA413	Bird Mtn. Meadows	1530 m	TSME/PHEM-VADE	8	CMT
45SA414	Wood Lake	1542 m	TSME	2	old trail
45SA420	*Ayun-ash*	1180 m	ABAM/VAME-XETE	7	old Crest trail
45SA421	Sheep Lakes	1250 m	ABLA/XETE	1	none
45SA424	Meadow Creek Trail	1088 m	ABAM	4	roasting pit, paddle, CMT
45SA425	Triangle Meadows	1390 m	TSME/PHEM-VADE	16	tipi rings, sweat lodge
45SA426	West Umtux	1481 m	TSME/PHEM-VADE	10	trail

TABLE 2.—(continued)

State no.	Name	Elevation	Plant association	Number of processing features	Associated features and artifacts
45SA427	Linear	1377 m	TSME/PHEM-VADE	16	circular depressions
45SA428	S. Gifford Way	1463 m	TSME/PHEM-VADE	7	trail
45SA429	Lemei Lake	1487 m	TSME/PHEM-VADE	2	trail
45SA430	Junction Lake	1445 m	TSME/PHEM-VADE	8	trail, lithics
45SA431	Cultus Campground	1218 m	TSME/VAME-XETE	1	lithics
45SA432	Surprise Crest	1289 m	TSME	1	trail
45SA433	Tombstone Lake	1390 m	TSME/PHEM-VADE	3	trail
45SA434	Adi Lake	1378 m	TSME/PHEM-VADE	4	trail
45SA435	Muddy Meadows	1341 m	TSME	1	trail
45SA436	Swampy Meadows	1198 m	TSME	5	none
45SA437	Swampy Meadows #2	1195 m	TSME	1	none
45SA446	Cultus Creek	1103 m	ABAM/VAME-XETE	11	trail, CMTs, artifacts
45SA447	Cultus Lake	1554 m	TSME/PHEM-VADE	1	trail
			Total:	**274**	

(38 Total Sites)

ABAM: *Abies amabalis*; ABLA: *Abies lasiocarpa*; PHEM: *Phyllodoce empetriformis*; RHAL: *Rhododendron albiflorum*; TSME: *Tsuga mertensiana*; VADE: *Vaccinium deliciosum*; VAME: *Vaccinium membranaceum*; XETE: *Xerophyllum tenax*; CMT: Culturally modified tree.

FIGURE 7.—*Tsuga mertensiana/Phyllodoce empetriformis/Vaccinium deliciosum* plant community at Big Meadow Camp (45SA338). Photograph by Cheryl A. Mack, USDA Forest Service, 1992.

States Geological Survey, described the various causes of fires on what is now the Gifford Pinchot National Forest. He wrote that Indians started fires to, among other things, promote the growth of huckleberries (1900:135). Forest Service Fire Reports for the years 1904 and 1905 attribute half of the fires on the forest to intentional burning by Indians (Allen 1904, 1905). These fires occurred in or adjacent to existing huckleberry patches, removing predominantly immature trees.

It is likely that our current understanding of site distribution is influenced by sampling bias, as well as differences in site discoverability. Berry processing sites are more visible and hence easier to find at higher elevations, where tree growth is very slow. But slower regrowth also means that berry patches last longer at high elevations, and therefore we would expect more extensive evidence of use. Aside from a stated cultural preference for its sweetness, *V. deliciosum* may also have been suitable for picking later in the season, due to its frost tolerance. Because it is adapted to harsher environments than *V. membranaceum,* it may also have been available in years when the *V. membranaceum* crop failed. It is also possible that these mountain hemlock/subalpine meadow plant communities were generally a more predictable source of huckleberries over time, providing a level of resource reliability not possible with transitory, fire-created patches (Mack and McClure 1996). The feasibility of logistically-organized intensive huckleberry production was obviously dependent upon such predictable resource quantities.

FIGURE 8.—Feature 13, *Vaccinium* processing feature, Big Meadow Camp (45SA338). Photograph by Richard H. McClure, USDA Forest Service, 1995.

FEATURE STRUCTURE: EXCAVATIONS AT BIG MEADOW CAMP (45SA338)

To better understand the archaeology of *Vaccinium* processing, excavation of a representative drying trench feature was conducted in 1995. Under the auspices of the Forest Service *Passport in Time* public archaeology program, a crew of trained volunteers assisted in the detailed investigation of one of 65 features at Big Meadow Camp (45SA338), in the heart of the Indian Heaven Wilderness. Feature 13 was selected for its average size and appearance, and because it lacked surface evidence of an associated log, suggesting possible prehistoric age. One of our research goals was to obtain samples suitable for radiocarbon dating. Also, by completely exposing the feature, we hoped to provide a comparison between surface and subsurface characteristics.

A grid was imposed over the feature, and surface vegetation removed. The sod layer, largely a mass of rootlets from surface vegetation, was peeled back, exposing the original charcoal-stained surface of the feature and associated rocks (Figure 8). Surface mapping involved plotting exposed rocks and collecting elevation measurements. Mapping data were later digitized in an AutoCAD program for plotting as a contour map (Figure 9). When mapping was complete, a 1-m × 2-m trench was excavated to bisect the north end of the feature and provide a cross-section profile (Figure 10). Sediments removed from the trench were initially screened through 3-mm mesh to isolate any associated artifact material. Excavations were arbitrarily terminated at a depth of 50 cm below datum, approximately 40 cm below ground surface.

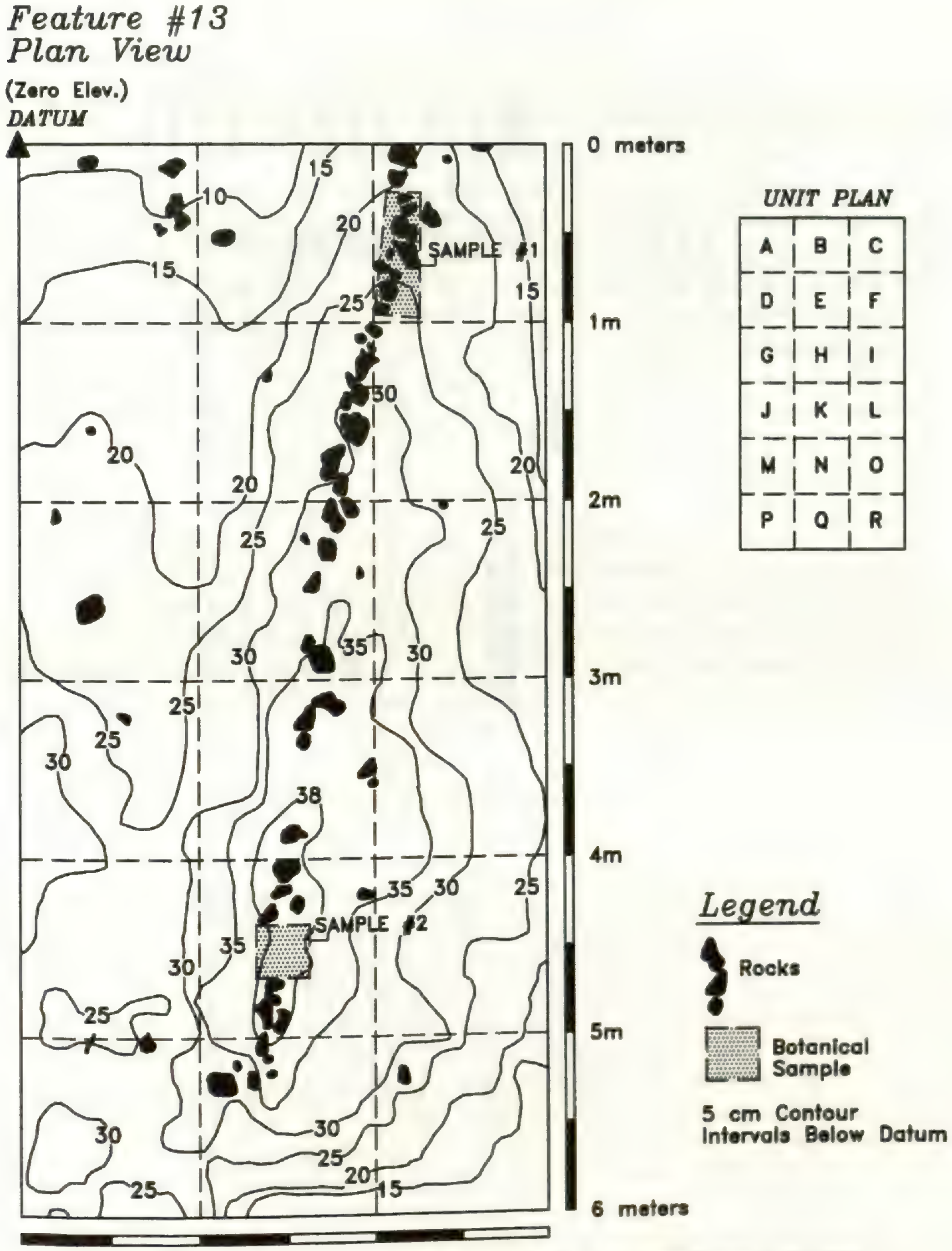
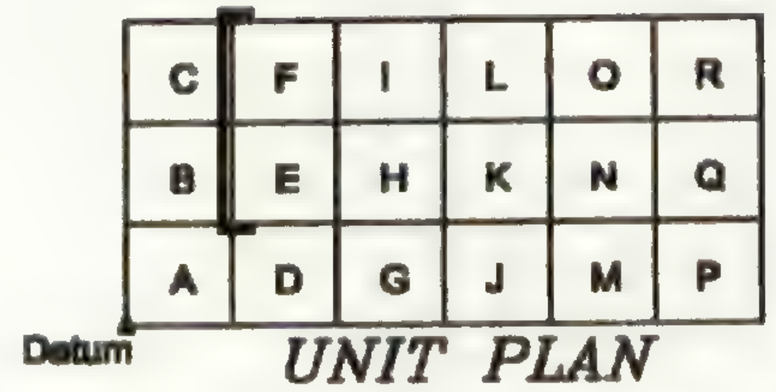


FIGURE 9.—Plan view contour map of Feature 13, Big Meadow Camp (45SA338).

In cross-section, Feature 13 is a depression, 14 cm to 18 cm in depth and 1.8 m wide, with rocks positioned at its base. A dense but thin layer of charcoal, 2 cm to 4 cm in thickness (Stratum II), lies at the base of the trench, east of the rocks. As seen in the profile, charcoal is concentrated on the side of the trench opposite the low mound of soil that parallels the trench. The log which served as the heat

Big Meadow Camp
45SA338
Feature #13
Profiles



UNIT PLAN

Unit C
South Wall

Unit B
South Wall

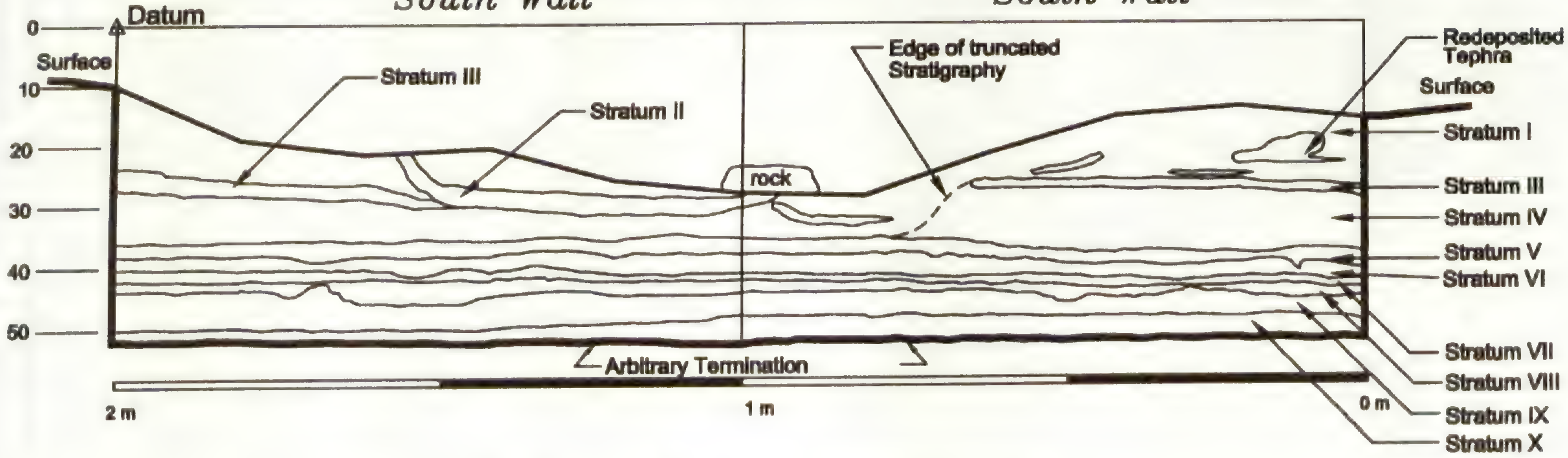


FIGURE 10.—Stratigraphic cross-section profile, Feature 13, Big Meadow Camp (45SA338).

source would have been located here, and presumably the charcoal originated from either the burned log, or from the fuel material used to ignite the log.

The stratigraphic profile includes three distinct layers of volcanic tephra. Tephra samples were collected and submitted to Dr. Nick Foit, Geochemical Laboratory, Department of Geology, Washington State University, for identification using electron microprobe analysis. The uppermost of these (Stratum III) was identified as Mount St. Helens *We* tephra, deposited during the Kalama eruptive event of A.D. 1482 (Mullineaux 1996:73). This deposit was truncated by the construction of the *Vaccinium* processing trench (Figure 10). Mottled sediments of Stratum I, near the surface of the mound west of the trench, result from displacement and mixing of the tephra. Two thin ash deposits from an older volcanic eruption (Stratum VII and Stratum IX) occur deeper in the soil profile, but were undisturbed by trench construction.

The excavation of Feature 13 provided a great deal of information about the archaeological signature of berry processing activity. In most respects, Feature 13 was average in size and appearance, and it contained over 70 rocks of cultural origin. The majority were arranged in a single line down the base of the trench, with a few found along the top and sides of the mound.

Three matrix samples of approximately 1.4 liters each were collected for archaeobotanical analysis during the excavation of Feature 13. Locations of samples are shown in Figure 9. Samples were selected from areas containing visible quantities of charcoal and oxidized soil, and consist primarily of Stratum II material. The samples were analyzed by Dr. Nancy Stenholm, Botana Labs, Seattle, Washington and results provided in a letter report (Stenholm 1995). Charred conifer needles from one of the samples produced an AMS radiocarbon date of 70 $\pm$ 40 B.P. Mature seeds of plantain (*Plantago lanceolata* L.), an alien species, were also identified in the sample, suggesting an historic period age for the feature. Results of sample analysis, discussed below, also provide evidence of feature function.

ARCHAEOBOTANICAL SAMPLING

A series of fourteen archaeobotanical samples were collected in 1990 from nine trench features at Tipi Pole Camp, Little Huck Camp, and Heart Lake (Mack 1992). These samples were derived from 10-cm diameter probes. At several sites, samples were collected from multiple locations within the same feature, in order to determine which part of the feature would most likely yield archaeobotanical remains. Four control samples were also collected outside of trench features. An additional six samples were collected in 1995, from Features 13 and 14 at Big Meadow Camp. All samples were submitted to Dr. Nancy Stenholm of Botana Labs, Seattle, Washington, for archaeobotanical analysis (Stenholm 1990, 1995).

Charred fruits, seeds and tissue of *Vaccinium* were recovered from seven of these samples. It is notable that of the fourteen samples collected from probes in 1990, only two produced charred *Vaccinium* remains, in contrast to five of the six samples collected in 1995. The visibility provided during exposure and excavation of Feature 13 clearly revealed the extent and location of burned material within the feature, and samples were collected to optimize recovery of botanical remains. The samples collected from probes in 1990 were collected from a variety of lo-

cations within the features, since it was not apparent from the surface of the feature where burned material was concentrated.

Size and appearance of carbonized fruits suggest either *Vaccinium deliciosum* or *V. membranaceum,* fully ripe at burning. This would indicate processing in mid-dle to late summer. Nearly entire fruits were recovered in samples from 45SA207, 45SA263, and 45SA338. Samples also contained a shiny amorphous black material with bubble or steam cavities identified as processed edible tissue (PET). Stenholm (1995) defines this as "tissue which resembles sugar-laden fruit or berry tissue without the seeds."

Archaeobotanical samples also included charred fragments of worked wood, including possible tool fragments. Samples from sites 45SA207 and 45SA263 in-clude small plank or board fragments. One of the samples from 45SA207 also produced the fragmentary end of a small pole, 2 cm in diameter, with probable cut marks. Samples from 45SA263 included a fragment of a flattened or spatulate object with a worn knife-like end, the worn tip of a wood implement, and two flattened or tabular items with worn convex ends. A charred fragment of a worn tool tip was also recovered from a Feature 14 sample. The tiny fragment of cedar or hemlock may have been part of a skewer or slat.

Three bulrush seeds were also recovered from Feature 14 samples, most likely representing the species *Scirpus validus* Vahl. The stems of various species of bul-rush, referred to locally as tule, were used for making the mats on which the berries were spread to dry. Although *S. validus* is not often mentioned as an eco-nomically important species (Stenholm 1995:7), it is the species that grows in Trout Lake, an area identified by local Indian people as a place where tules were collected while traveling to the berry camps (Billy 1992, 1995).

Comparison of the 1990 samples with those collected in 1995 at Big Meadow Camp indicate significant differences in tree species composition among the sam-pled sites. Botanical assemblages from lower elevation berry processing sites con-tain high percentages of early seral species, such as Douglas-fir (*Pseudotsuga men-ziesii* (Mirbel) Franco) and willow (*Salix* spp.), as fuelwood. Floral composition at most of these sites today is quite different, with climax populations of Pacific silver fir (*Abies amabilis* (Dougl.) Forbes) as the dominant tree type. Species rep-resented in the samples from the higher elevation site of Big Meadow Camp, primarily mountain hemlock (*Tsuga mertensiana* (Raf.) Sarg.), are the same as found on-site today. These differences suggest that fire-induced succession, whether natural or caused by humans, had a greater impact on species compo-sition at the lower elevation sites. Species composition in high elevation commu-nities is more constant.

SITE CHRONOLOGY

These sites have been dated with the help of ethnohistoric sources, tree-ring dating, and radiocarbon dating. Historic references provide dates of use for a num-ber of sites with archaeological features. One example comes from the 1853 journals of the McClellan expedition, which included ethnographer George Gibbs. McClel-lan and his survey party camped with 138 Klickitat Indians at a site called ***Che-quoss*** in August of 1853. The Indian camp of ***Chequoss*** most likely corresponds to

the site recorded as Green Lake (45SA292). According to Gibbs, the Indians at ***Chequoss*** were occupied in "feasting on strawberries and the mountain whortleberry" (1855:404). Whortleberry is another name applied to the huckleberry.

Use of several archaeological sites occurred within the living memory of tribal elders consulted as a part of our research. Based on their accounts, we know that ***SkIs-xaLia*** (45SA262) and ***Ayun-ash*** (45SA420) were still used in the 1920s and 1930s. *Vaccinium* processing features identified at ***Kpss-wa-nite*** (45SA265) and ***IskIs Watum*** (45SA364, 45SA365, 45SA375) may correspond to those photographed in use between 1933 and 1935.

Ethnographic research has established a link between huckleberry processing sites and another site type which is directly dateable through tree-ring counting. Numerous accounts describe how the bark of cedar trees was removed to make folded bark baskets, used to hold the surplus harvest of berries. Schlick (1994) describes these bark containers as expediency baskets, manufactured as needed in order to bring home the surplus harvest of berries. Lieutenant Johnson Kelly Duncan, topographer for the McClellan expedition in 1853, painted a watercolor miniature of two folded bark baskets, while camped at ***Chequoss,*** labeled "Cedar Bark Baskets—Klick-a-tat." Trees from which the bark was removed exhibit a characteristic scar. We have documented over 6,000 peeled cedar trees in the Forest, all with tool marks resulting from purposeful bark removal. The majority of these trees cluster along the periphery of historic huckleberry patches. Bark peeling dates from these cedars corroborate dates of occupation of nearby ethnographically-documented sites.

The site of ***Kalama't*** (45SA291) provides a good example, although there are numerous others. ***Kalama't,*** known today as the Indian Race Track, was a summer berry camp used by mid-Columbia River Indians. Use of the ***Kalama't*** area as a huckleberry patch has been documented archaeologically, through ethnographic and historic sources, and through the recollections of living Indian people. The site is included in Verne Ray's 1936 inventory of Klickitat villages and camps, where it is referred to as a summer camp and racetrack, in use in the period after 1850 (Ray 1936:149). Numerous historical features have been documented at the site, including a linear racetrack, tipi rings, sweat lodge remains, and the remains of huckleberry drying trenches. Internal Forest Service records as well as articles from local newspapers indicate that use of ***Kalama't*** was at a peak in the period between 1890 and 1910. Over 400 peeled cedar trees have been documented within 5 km of ***Kalama't***. Peeling dates recorded at these sites range from A.D. 1852 to 1950, with a peak in use between 1890 and 1910 (Mack 1996:35).

Analysis of peeling dates from cedar trees to the south of Red Mountain has helped to pinpoint the period of use of another, older berryfield in that area. The site of ***Chequoss*** was the place where Captain McClellan camped with 138 Klickitat Indians in August of 1853. Peeling dates from three peeled cedar sites, containing 323 trees, located to the south of ***Chequoss*** indicate use of that area from A.D. 1804 to 1911, with a peak in use in the decade after 1850. After 1890 the site appears to have been rather abruptly abandoned, perhaps due to declining huckleberry yields.

We have collected a total of 235 tree ring dates from peeled cedars, ranging from A.D. 1720 to 1950. It is probably our best tool for determining the age of

adjacent berry processing sites used within the last 300 years. Based on an analysis of the range of peeling dates at a number of sites, it appears that the average duration of use of a huckleberry patch was between 40 and 70 years. This would have varied based on the size of the huckleberry patch, with larger patches remaining productive over a longer time period.

We know that if huckleberry patches are created and maintained by fire, they eventually revert back to forest when fires no longer occur. A few of the sites that we have recorded are situated within mature forests. These sites were most likely initially occupied following a forest fire event, which destroyed the forest cover and provided productive, though temporary, huckleberry habitat. Overstory trees present at these sites today most likely became established during the time the sites were in use as huckleberry camps, and their subsequent growth would ultimately have led to site abandonment, when shade resulted in declining huckleberry yields. For those sites in forested settings, it is possible to determine the overall age of the trees growing on the site through tree ring counting, using an increment bore. If the assumption that the current overstory trees began growing during the latter part of the period of site use is correct, then the age of these trees should give an indication of the age of the site. The range of tree ring counts at the Swampy Meadows site indicated the existing overstory trees began growing at the site between A.D. 1816 and 1860. We then compared these dates to the peeling dates from the closest peeled cedar site to Swampy Meadows, and found the range of peeling dates there indicated use between A.D. 1816 and 1847.

Thirteen charcoal samples were collected from individual trench features at five sites and submitted for dating. Resulting age determinations range from 600 ± 50 years B.P. to 100 ± 80, with two samples reported as "modern" (Mack 1992: 12). The three oldest dates are from Tipi Pole Camp (45SA207), a site that was in use in 1910. In considering these results, we realized that some of the wood charcoal samples submitted for dating could represent "old wood"—very old slow-growing trees that stood as snags for some time before utilization in *Vaccinium* processing. Because of this "old wood effect," we do not believe the earlier dates provide reliable age determinations for berry processing events.

To obtain age determinations that more accurately reflect the *Vaccinium* processing activities, we subsequently submitted samples consisting of charred needle fragments from Feature 13 and Feature 14 at Big Meadow Camp (45SA338). Presumably, the needles represent fuel material used to ignite a downed log. Based on the lack of ethnohistoric data specific to this site, an absence of associated historic artifact material, and the almost completely deteriorated condition of the drying logs, we felt that both features might be of prehistoric age. The samples produced AMS dates of 70 ± 40 B.P. and 350 ± 40 B.P., indicating both prehistoric and historic period use of this site. A charred *Vaccinium* fruit recovered in the archaeobotanical sample from Feature E-1 at the Heart Lake site (45SA263) was also submitted for AMS dating. The berry tissue produced a date of 150 ± 50 B.P.

DISCUSSION

Aside from providing insight into one resource procurement activity, research into the age of these features has important bearing on our understanding of

changing land use patterns in the late prehistoric period. Huckleberries are notable in that they were available in quantities suitable for collection as a stored food, and they could be dried to a raisin-like consistency and stored over the winter. The ability of late prehistoric Columbia River peoples to remain in semi-permanent villages was dependent on their ability to accumulate stored resources for winter use. For people who lived almost a third of the year on stored foods, dried huckleberries provided an important wintertime source of vitamin C.

Some researchers have suggested that intensive huckleberry collection and processing is directly related to equestrianism (Schalk and Atwell 1994, in Burtchard 1997). The argument used by Schalk and Atwell, namely that it was not feasible to transport huckleberries in bulk from the uplands prior to the introduction of the horse, is weak, given that the technology for transport existed, as evidenced by tumplines used to carry larger pack baskets across the back (Figure 2). Additionally, the archaeological record points to an intensification of root gathering and processing in the uplands of the region ca. 500 B.C.–A.D. 1000 (Chatters and Pokotylo 1998:78), long before the arrival of the horse. A discussion of alternative means of transporting food in the pre-horse era, such as the use of dogs, is beyond the scope of this paper, although linguistic and ethnographic data from the Plateau suggests that dogs functioned as beasts of burden in the pre-horse era (Kennedy and Bouchard 1998:244; Stern 1998:397).

Establishing the time depth of this activity is important, since this bears directly on the question of whether intensive processing of huckleberries is related to equestrianism or resource intensification. The results of our dating efforts indicate that bulk processing of huckleberries does pre-date the introduction of the horse in this area. Most researchers agree that resource intensification strategies increased during the late prehistoric period in response to increasing population density (Burtchard 1990, 1997). Berry drying features provide clear evidence for bulk processing of a seasonally abundant commodity. In the Northwest, the shift from a generalized foraging adaptation to a more logistically organized system, with seasonally occupied specialized sites, began some time in the mid-Holocene, ca. 5000 to 3000 years B.P. (Ames and Marshall 1980; Schalk 1980; Schalk and Cleveland 1983; Chatters 1989; Burtchard 1990). Intensive processing of huckleberries might well represent one component of the regional trend in resource intensification.

ACKNOWLEDGMENTS

Elders who participated in these activities during the 1920s and 1930s generously provided information regarding the history of berry camps and descriptions of the drying process. We would like to thank Elsie Dick and Louise Billy for sharing this information, Frederick Ike, Sr. for help in arranging 1992 and 1995 interviews, and Sam Jim and Elaine Howtopat for their services as interpreters. Clifford Washines, of the Yakama Nation Cultural Resources program, also provided important information. Dave Cox prepared the illustrations of the excavated feature. Dana Lepofsky, Don Minore, and Nancy Diaz reviewed earlier drafts of the paper. We gratefully acknowledge their comments.

NOTES

[1] Mamie Smith, Yakama Indian Nation, conversation April 11, 1995.

REFERENCES CITED

Abraham, Eleanor. 1963. Huckleberry harvest attracts Indians to Mt. Adams country. *The Rainier News.* Ranier, Oregon.

Allen, Grenville F. 1904. Report of fires in the Mount Rainier Forest Reserve. Record Group 95, Box 7, Records of the Office of Forest Reserves, 1904–1907. National Archives and Records Administration, Washington, D.C.

———. 1905. Report of fires in the Mount Rainier Forest Reserve. Record Group 95, Box 7, Records of the Office of Forest Reserves, 1904–1907. National Archives and Records Administration, Washington, D.C.

Ames, Kenneth M. and Alan G. Marshall. 1980. Villages, demography and subsistence intensification on the southern Columbia Plateau. *North American Archaeologist* 2(1):25–52.

Benson, Eva M., Jean M. Peters, Margaret A. Edwards, and Louise A. Hogan. 1973. Wild edible plants of the Pacific Northwest. *Journal of the American Dietetic Association* 62:143–147.

Billy, Louise. 1992. Videotape interview conducted by Cheryl Mack, September 1992, Trout Lake, Washington. Interview transcript on file, Gifford Pinchot National Forest Heritage Program, Trout Lake, Washington.

———. 1995. Videotape interview conducted by Cheryl Mack, August 1995, Trout Lake, Washington. Interview transcript on file, Gifford Pinchot National Forest Heritage Program, Trout Lake, Washington.

Boyd, Robert. 1996. *People of The Dalles: The Indians of Wascopam Mission.* University of Nebraska Press, Lincoln and London.

Briley, Ann. 1986. *The Lonely Pedestrian: Francis Marion Streamer.* Ye Galleon Press, Fairfield, Washington.

Burtchard, Greg C. 1990. The Posy Archaeological Project: Upland Use of the Central Cascades, Mt. Hood National Forest. Report submitted to USDA Forest Service, Mt. Hood National Forest, Gresham, Oregon. On file, Laboratory of Archaeology and Anthropology, Portland State University, Portland, Oregon.

———. 1997. Environment, land-use & archaeology of Mt. Rainier National Park, Washington. On file, US Department of the Interior, National Park Service, Seattle.

Chatters, James C. 1989. Resource intensification and sedentism on the Southern Plateau. Archaeology in Washington 1: 3–19. Bellingham, Washington.

Chatters, James C., and David L. Pokotylo. 1998. Prehistory: introduction. In *Handbook of North American Indians,* Vol. 12, ed. Deward E. Walker, Jr., pp. 73–80. Smithsonian Institution, Washington.

Curtis, Edward S. 1911a. *The North American Indians.* Vol. 7. The Plimpton Press, Norwood, Massachusetts.

———. 1911b. *The North American Indians.* Vol. 8. The Plimpton Press, Norwood, Massachusetts.

Diaz, Nancy M., Diane E. Smith, and Christopher Topik. 1996. *Plant Association and Management Guide for the Mountain Hemlock Zone, Gifford Pinchot and Mt. Hood National Forests.* Pacific Northwest Region Publication R6-MTH-GP-TP-08-95, USDA Forest Service.

Dick, Elsie. 1992. Videotape interview conducted by Cheryl Mack, September 1992, Trout Lake, Washington. Interview transcript on file, Gifford Pinchot National Forest Heritage Program, Trout Lake, Washington.

———. 1995. Videotape interview conducted by Cheryl Mack, August 1995, Trout Lake, Washington. Interview transcript on file, Gifford Pinchot National Forest Heritage Program, Trout Lake, Washington.

Dunnicliffe, Fred. 1911. At Indian Race Track. *White Salmon Enterprise* 9(20):1 (September 8).

Filloon, Ray M. 1952. Huckleberry pilgrimage. *Pacific Discovery* 5(3):4–13.

French, David. 1957. Aboriginal control of huckleberry yield in the Northwest. Paper presented at the annual meeting of the American Anthropological Association, Chicago.

———. 1965. Ethnobotany of the Pacific Northwest Indians. *Economic Botany* 19: 378–382.

Gibbs, George. 1855. Report of Mr. George Gibbs to Captain McClellan, on the Indian tribes of the Territory of Washing-

ton. Reports of Explorations and Surveys to Ascertain the Most Practicable and Economical Route for a Railroad from the Mississippi River to the Pacific Ocean 1:402–434. Executive Document No. 78, 2nd Session, 33rd Congress, 1853–54. Washington, D.C.

———. 1877. Tribes of western Washington and northwestern Oregon. *U.S. Geographical and Geological Survey of the Rocky Mountain Region, Contributions to North American Ethnology* 1(2):157–241. Washington, D.C.

Hilty, Ivy E. 1972. Nutritive values of native foods of Warm Springs Indians. *Extension Circular* 809. Extension Service, Oregon State University, Corvallis.

Hines, Donald. 1992. *Ghost Voices: Yakima Indian Myths, Legends, Humor and Hunting Stories.* Great Eagle Publishing, Issaquah, Washington.

Hunn, Eugene S. 1990. *Nch'i Wana: "The Big River"—Mid-Columbia Indians and Their Land.* University of Washington Press, Seattle.

Jacobs, Melville M. 1934. *Northwest Sahaptin Texts.* Columbia University Contributions to Anthropology 19(1). New York.

Keely, Patrick B. 1980. Nutrient Composition of Selected Important Plant Foods of the Pre- contact Diet of the Northwest Native American Peoples. Unpublished M.S. Thesis (Nutritional Sciences and Textiles), University of Washington, Seattle.

Kennedy, Dorothy I.D., and Randall T. Bouchard. 1998. Northern Okanagan, Lakes, and Colville. In *Handbook of North American Indians,* Volume 12, ed. Deward E. Walker, Jr., pp. 238–252. Smithsonian Institution, Washington, D.C.

Langdon, James. 1938. Twin Buttes Recreation Unit. Recreation Atlas on file, Gifford Pinchot National Forest Heritage Program, Trout Lake, Washington.

McClellan, George B. 1853. Journal, May 20–December 15. Library of Congress.

Mack, Cheryl A. 1992. In pursuit of the wild *Vaccinium*: huckleberry processing sites in the southern Washington Cascades. *Archaeology in Washington* 4:3–16.

———. 1996. *A Summary of Archaeological Data Recovery at Twenty-four Culturally Modified Tree Sites on the Gifford Pinchot National Forest.* USDA Forest Service, Pacific Northwest Region, Gifford Pinchot National Forest, Vancouver, Washington.

Mack, Cheryl A. and Richard H. McClure. 1996. The fruits of their labors: *Vaccinium* processing in the Washington Cascades. Paper presented at the 49th Annual Northwest Anthropological Conference. Moscow, Idaho, March 14–16, 1996.

Martin, Virginia Beavert. 1979. Summary of Yakima Indian Treaty Relations, and Use of the Gifford Pinchot National Forest. Unpublished report on file, Gifford Pinchot National Forest Heritage Program, Trout Lake, Washington.

Miss, Christian J. and Margaret A. Nelson. 1995. Data Recovery at the Mule Spring Site, 45-KI-435, King County, Washington. Report on file, Mt. Baker–Snoqualmie National Forest. Northwest Archaeological Associates, Inc., Seattle.

Mudge, Zachariah. 1854. *Sketches of Mission Life among the Indians of Oregon.* Carlton & Porter, New York. Reprinted 1983 by Ye Galleon Press, Fairfield, Washington.

Mullineaux, Donal R. 1996. Pre-1980 tephra-fall deposits erupted from Mount St. Helens, Washington. U.S. Geological Survey Professional Paper 1563. Washington, D.C.

Murdock, George P. 1980. The Tenino Indians. *Ethnology* 19:129–49.

Norton, Helen, Robert Boyd, and Eugene S. Hunn. 1983. The Klickitat Trail of south-central Washington: a reconstruction of seasonally used resource sites. In *Prehistoric Places on the Southern Northwest Coast,* ed. Robert E. Greengo, pp. 121–152. Thomas Burke Memorial Washington State Museum, University of Washington, Seattle.

Osborne, William H. 1953. Northwest Indians' berry rights. *Nature Magazine* 46(9):482–484.

Plummer, Fred G. 1900. Mount Rainier Forest Reserve, Washington. Twenty-first Annual Report of the United States Geological Survey, Part V. Document 5, 56th Congress, 2nd Session.

Ray, Verne F. 1936. Native villages and groupings of the Columbia Basin. *Pacific Northwest Quarterly* 27(2):99–152. University of Washington, Seattle.

Relander, Click. 1959. "Definition of camps, huckleberry fields." Informants:

Thomas Yallup, Kelly George, Watson Totus, others. Typescript in the Relander Collection, Yakima Valley Regional Library, Yakima.

Rusk, C. E. 1924. *Tales of a Western Mountaineer.* Houghton Mifflin Company, Boston and New York. Reprinted 1978 by The Mountaineers, Seattle.

Schalk, Randall F. 1980. *Cultural Resource Investigations for the Second Powerhouse Project at McNary Dam, near Umatilla, Oregon.* Laboratory of Archaeology and History, Project Report 1, Washington State University, Pullman.

Schalk, Randall F. and Ricky G. Atwell. 1994. Research design for prehistoric archaeology. In Archaeological Investigations, PGTOPG&E Pipeline Expansion Project, Idaho, Washington, Oregon, and California; Vol.1, Project Overview, Research Design and Archaeological Inventory, ed. Michael J. Moratto, pp. 1–42. Prepared for Bechtel Corporation, San Francisco; INFOTEC Research, Inc., Fresno, California; and Far Western Anthropological Research Group, Inc., Davis, California.

Schalk, Randall F. and Gregory Cleveland. 1983. A chronological perspective on hunter-gatherer land use strategies in the Columbia Plateau. In *Cultural Resource Investigations for the Lyons Ferry Fish Hatchery Project, near Lyons Ferry, Washington,* ed. Randall F. Schalk, pp. 11–56. Laboratory of Archaeology and History, Project Report 8, Washington State University, Pullman.

Schlick, Mary Dodds. 1994. *Columbia River Basketry, Gift of the Ancestors, Gift of the Earth.* University of Washington Press, Seattle.

Schuster, Helen. 1975. Yakima Indian Traditionalism: A Study in Continuity and Change. Unpublished Ph.D Dissertation, Department of Anthropology, University of Washington, Seattle.

Smith, Allan H. 1964. Ethnographic Guide to the Archaeology of Mt. Rainier National Park. Mimeographed report prepared for the National Park Service. Department of Anthropology, Washington State University, Pullman.

Spier, Leslie and Edward Sapir. 1930. Wishram ethnography. *University of Washington Publications in Anthropology* 3:151–300. Seattle.

Stabler, H. O. 1910. Special Fire Report of 1910, Columbia National Forest. Report dated November 5, 1910, original on file, Gifford Pinchot National Forest, Vancouver, Washington.

Stenholm, Nancy. 1990. Botanical assemblage of Indian Heaven Wilderness huckleberry drying features. Letter report to South Zone Archaeologist, Gifford Pinchot National Forest, Trout Lake, Washington.

———. 1995. Botanical assemblage of Big Meadow huckleberry drying features. Letter report to Forest Archaeologist, Gifford Pinchot National Forest, Vancouver, Washington.

Stern, Theodore. 1998. Cayuse, Umatilla, and Walla Walla. In *Handbook of North American Indians,* Vol. 12, ed. Deward E. Walker, Jr., pp. 395–419. Smithsonian Institution, Washington, D.C.

Wilcox, Arthur. 1911. The Columbia National Forest, Its Resources and Their Protection. Report dated January 17, 1911. Original on file, Gifford Pinchot National Forest, Vancouver, Washington.

Journal of Ethnobiology 22(1): 61–102 Summer 2002

UNDERDIFFERENTIATED TAXA AND SUBLEXICAL CATEGORIZATION: AN EXAMPLE FROM MATSES CLASSIFICATION OF BATS

DAVID W. FLECK,[a] ROBERT S. VOSS,[b] and NANCY B. SIMMONS[b]

[a]*Department of Linguistics, Rice University, Houston, TX 77251-1892*
[b]*Department of Mammalogy, American Museum of Natural History, New York, NY 10024-5192*

ABSTRACT.—This study looked at the classification of bats by the Matses Indians of Amazonian Peru using four methods: 1) interviews; 2) elicitation of bat names using freshly-captured zoological specimens; 3) grammatical analysis of bat terminology; and 4) analysis of recorded texts about bats. The results showed that although the Matses have only one lexicalized name for referring to bats (of which 57 species have been collected at one Matses village), they recognize morphological and behavioral diversity in the local bat fauna at the level of family, subfamily, genus, or species. We suggest methods for identifying unnamed terminal taxa in folk classification systems, and explore the taxonomic and cognitive nature of sublexical folk-biological terminal taxa. Implications of our results for biological inventory fieldwork are briefly discussed.

Key words: Matses, bats, folk classification, nomenclature, Amazonia

RESUMEN.—Este estudio examina la clasificación de murciélagos por los Matsés de la Amazonía Peruana usando cuatro métodos: 1) etrevistas; 2) elicitación de nombres de murciélagos usando especímenes recién capturados; 3) análisis gramatical de la terminología referente a murciélagos; y 4) análisis de grabaciones de textos sobre murciélagos. Los resultados revelaron que aunque los Matsés tienen sólo un nombre lexicalizado referente a murciélagos (de los cuales hemos capturado 57 especies alrededor de un solo pueblo Matsés), ellos reconocen diversidad en la morfología y conducta de la fauna local de murciélagos al nivel de familia, subfamilia, género, o especie. Aquí sugerimos métodos para la identificación de taxones (categorías biológicas) terminales no nombradas en sistemas de clasificación tradicionales, y exploramos la base taxonómica y cognitiva de taxones terminales en sistemas de nomenclatura biológica tradicional. Discutimos brevemente las implicaciones de nuestros resultados para el trabajo de campo de inventario biológico.

RÉSUMÉ.—Cette étude examine la classification des chauve-souris par les Indiens Matses de l'Amazonie péruvienne en utilisant quatre méthodes: 1) des entrevues; 2) la présentation aux Matses de spécimens récemment capturés pour découvrir le nom des chauve-souris; 3) analyse grammaticale de la terminologie des chauve-souris; et 4) analyse d'enregistrements de textes concernant les chauve-souris. Les résultats montrent que bien que les Matses n'aient qu'un seul nom lexicalisé pour parler des chauve-souris (dont 57 espèces ont été capturées dans un seul village), ils en reconnaissent la diversité dans la morphologie et le comportement au niveau de la famille, la sous-famille, le genre, ou l'espèce. Nous suggérons des méthodes

pour identifier des taxa terminaux sans noms, et nous explorons la nature taxonomique et cognitive des taxa terminaux dans les systèmes traditionels de classification. Nous présentons aussi brièvement l'implication des nos résultats pour les inventaires sur le terrain.

INTRODUCTION

A common finding in ethnobiological classification studies is that some local biological species get lumped into a single named category with no named subordinate categories. The conclusion usually drawn from such observations is that the people whose classification system is being studied are less acute observers of biological diversity than are Western scientists for the organisms in question. Although the inference seems self-evident, it could be misleading if non-scientists consistently recognize some species that they simply do not name. If covert (sublexemic) species recognition is a widespread phenomenon, the use of linguistic criteria to determine which folk categories are considered for comparisons of classification systems could significantly underestimate the ability of traditional societies to discriminate taxa. To emphasize the language-based nature of such comparisons, we refer to situations where a named terminal folk taxon includes more than one biological species by the term "lexical underdifferentiation."

In published ethnobiological studies wherein criteria for accepting or rejecting informant responses have been stated explicitly, names (lexemes habitually used to label taxonomic categories) are distinguished from *ad hoc* descriptive phrases, and only named categories (or categories labelled by terms of ambiguous lexemic status) are considered as relevant data (Berlin et al. 1974; Hunn 1977; Hays 1983; Hunn and French 1984). The inevitable outcome of such methodology is that researchers do not actively look for ethnobiological categories below named terminal taxa. Under a theoretical position that consistent linguistic labeling is required for human category formation, it would be justified to disregard such unnamed entities. However, this assumption has not been substantiated, and there is evidence that folk biology may be a fertile hunting ground for examples of sublexemic categorization. Thus, Diamond and Bishop (1999:37) found that in two out of three cases of lexical underdifferentiation of the local bird fauna by the Ketengban of Indonesian New Guinea, informants ". . . were aware of the differences between the two species bearing the same name." Similarly, Dwyer (1976:434) reported that the Rofaifo of Papua New Guinea recognize five folk-taxonomic mammalian categories ("Rofaifo species") ". . . for which no formal lexeme is available." Unfortunately, all of these interesting cases were mentioned only in passing, and none was formally analyzed. Among the few exceptions to this trend, Bulmer and Menzies (1972, 1973) described several sublexemic folk-zoological taxa recognized by the Karam in some detail.

Curiously, the disregard for unnamed categories is not consistent in ethnobiology. "Covert categories" (unnamed midlevel groupings of named taxa) and unnamed "unique beginners" (highest-level taxonomic categories), by contrast, have received much attention (Berlin et. al 1968; Berlin 1974; Brown 1974; Hays 1976; Atran 1983; Taylor 1984). This inconsistency might be justified in a purely linguistic study, where covert midlevel and unique beginner categories delineate

groupings of lexemes that are relevant to the description of semantic domains. However, if the object of an ethnobiological project is to explore the perceptual and cognitive aspects of folk classifications, either in their own right or in comparison to other taxonomic systems, it does not make sense to dismiss lower-level folk categories based solely on lexemic labeling.

Understanding the relationship between folk-biological knowledge and lexemic labelling can have practical applications as well, notably for field biologists. Lists of local plant and animal names are often collected during botanical and zoological inventories, but the interpretation of such lists can be problematic (Prance 1984; Schultes 1986; Fleck et al. 1999; Wilkie and Saridan 1999). Whereas lexical overdifferentiation (in which one biological species corresponds to two or more nonsynonymous folk species names) can lead to inflated estimates of local biodiversity (Fleck et al. 1999), lexical underdifferentiation can result in equally misleading but oppositely biased estimates. Well researched examples of both phenomena are crucial for more informed applications of folk-taxonomic data in biodiversity research.

This paper explores the classification of bats (Mammalia: Chiroptera) by the Matses Indians of Amazonian Peru. Preliminary ethnobiological research (Fleck 1997) indicated that bats are lexically underdifferentiated by this indigenous rainforest culture, a hypothesis we subsequently tested in a collaborative field study of Matses ethnomammalogy. Using both traditional ethnobiological methods (interviews, listing requests, naming exercises, morpho-syntactic tests) and recorded monologues, we documented Matses knowledge of local bat diversity and natural history, and we analyzed how that information is linguistically encoded. Simultaneous sampling of the local bat fauna provided the necessary materials for naming exercises, a preliminary estimate of chiropteran diversity in our study area, and permanent documentation of the biological taxa described by Matses informants.

THE MATSES AND THEIR INTERACTIONS WITH BATS

The Matses (also known as Mayoruna; Panoan language family) are an indigenous Amazonian society consisting of about 1500 persons living along the Yavarí (Javari) River and its tributaries in Peru and Brazil. Prior to 1969, the Matses avoided contact by staying far from navigable rivers and maintaining hostile relations with neighboring non-tribal Peruvians and Brazilians (Romanoff 1984), although their ancestors may have had sporadic contact with Jesuit missions in prior centuries (Erikson 1994). In 1969, the Matses established first peaceful contact with Summer Institute of Linguistics personnel (Vivar 1975), and in the 1980s some groups moved away from the inland villages and settled on the banks of the Yaquerana (Upper Javari) and Gálvez Rivers. Acculturation of the Matses to the national culture is proceeding rapidly, but because of their recent isolation, older individuals (>30 years of age) still possess undiminished traditional knowledge. Many of the younger men speak Spanish or Portuguese at various levels of fluency, but about 85 percent of the Matses are still essentially monolingual. Most Matses still meet all their nutritional needs through traditional subsistence activ-

ities including hunting, fishing, trapping, horticulture and collection of wild foods.

Although the Matses have no subsistence or ritual interest in bats, it difficult for the Matses to avoid daily contact with them. For example, certain frugivorous species are pests that enter Matses houses to eat ripe plantains, and vampires occasionally bite sleeping Matses and their dogs and chickens. Other species roost in Matses buildings, particularly abandoned houses, where they make noise and leave feces. Bats visit Matses swiddens to eat plantains and papayas, and to roost in plantain leaves or under the bark of felled trees. While hunting, Matses frequently disturb bats that roost in foliage close to the ground, bat roosts in hollow trees are often found when felling trees for swiddens, and Matses remove armadillos from burrows that are often inhabited by bats. At dusk, bats can be seen flying around villages, and at night they can be heard vocalizing and swooping close to the ground outside houses. The Matses generally do not kill bats, except sometimes when they enter houses, or when boys on occasion use them for archery target practice. Apparently, the only Matses belief associated with bats is that forest spirits may manifest themselves as large, black bats that swoop down close to people's heads at night, causing them to become ill.

STUDY AREA AND THE REGIONAL BAT FAUNA

This study was conducted principally at the Matses village of Nuevo San Juan (73°9′50″W, 5°14′50″S, ca. 150 m above sea level), located on the Gálvez River (a left-bank tributary of the Yavarí River), in the district of Yaquerana, department of Loreto, northeastern Peru (Figure 1). Estimates of average annual rainfall (2900 mm) and average annual temperature (25.9°C) are available from Jenaro Herrera, the nearest weather station, located about 100 km west of Nuevo San Juan (Marengo 1983). The Gálvez is a blackwater river with a narrow floodplain that seldom extends more than 0.5 km on either side. The area around Nuevo San Juan is primary rainforest except for gaps from windfalls and active and abandoned swiddens (0.5–2 ha horticultural plots) that have been cleared annually since the village was established in 1984 (see Fleck and Harder [2000] for additional details about local habitats).

Over 100 species of bats could be expected to occur in Matses territory, as inferred from available geographic range data (summarized by Voss and Emmons 1996). Far from constituting a homogeneous group of confusingly similar forms (as a nonspecialist might suspect), this fauna includes many taxa that can be readily distinguished by size and other trenchant morphological differences. The Spectral Bat (*Vampyrum spectrum*; see Appendix A for all bat species authorities) and Greater Spear-nosed Bat (*Phyllostomus hastatus*), for example, are exceptionally large (>100 g), whereas the Thumbless Bat (*Furipterus horrens*) and Little Brown Bats (*Myotis* spp.) are tiny (<10 g). Although most bats are uniformly brownish or blackish, some are distinctively colored; those with distinctive markings include Spix's Disk-winged Bat (*Thyroptera tricolor,* with a sharply contrasting white chest), the Greater Sac-winged Bat (*Saccopteryx bilineata,* with two bright-white dorsal stripes), and Macconnell's Bat (*Ectophylla macconnelli,* with light-gray fur and bright yellow ears, noseleaf, and thumbs). Other taxonomically important

FIGURE 1.—Map showing our study site at Nuevo San Juan on the Gálvez River and other villages where Matses were interviewed or asked to record natural history accounts.

morphological differences concern the shape of prominent body parts: Sheath-tailed Bats (family Emballonuridae) are recognizable (among other traits) by their exceptionally mobile, fleshy rostrums; Free-tailed Bats (family Molossidae) by their dog-like faces and long tails that extend well beyond the flight membranes; Long-tongued Bats (subfamily Glossophaguinae) by their elongated muzzles; and Round-eared Bats (*Tonatia* spp.) by their exceptionally large, rounded ears.

Taxonomic differences in behavior are likewise obvious, even to casual observers. For example, the Proboscis Bat (*Rhynchonycteris naso)* typically roosts in characteristically linear groups on well lit tree trunks over water, where it can be seen on almost any daytime river trip in Amazonia. Many Neotropical Fruit Bats (subfamily Stenodermatinae) roost in tents that they construct from palm fronds and other large leaves in the forest understory, and Round-eared Bats (*Tonatia* spp.) roost in burrows that they excavate in arboreal termite nests. Some bats feed

exclusively on flying insects (e.g., families Emballonuridae, Vespertilionidae and Molossidae), but some Spear-nosed Bats (subfamily Phyllostominae) snatch crickets, katydids, and other crawling insect prey from leaves and stems. Other bats eat fish (*Noctilio leporinus*); blood (subfamily Desmodontinae); birds, rodents and other bats (*Vampirum spectrum*); fruit (subfamilies Carolliinae and Stenodermatinae); or flower nectar and pollen (subfamily Glossophaginae).

METHODS

Data for this study were collected during three field seasons, in 1994 (4 months), 1998 (3 months), and 1999 (3 months). Additionally, in 1995–1996, Fleck worked among the Matses for 20 months documenting their rainforest habitat classification system and their knowledge of non-flying mammal diversity, during which time he became moderately fluent in the Matses language.

Preliminary Interviews.—From April to July 1994, 12 Matses hunters from the villages of Nuevo San Juan, Remoyacu, and Buen Perú (Figure 1) were individually interviewed about the local mammal fauna in order to obtain a list of Matses mammal names. Once this initial list was compiled, 5 informants (Informants A–E) were selected to answer more detailed questions about the natural history of taxa in these lists. Because these earliest interviews were carried out before Fleck was fluent in Matses, they were conducted in the local Spanish dialect with bilingual Matses speakers. However, as soon as the Matses names for mammals were learned, these were used instead of the Spanish terms. Among other questions, each of the 5 informants was asked if there was more than one type of that named taxon; affirmative responses were followed up with a request to list the different kinds. In the case of bats, interviewees were asked, "¿Cuantas calidades de ***cuesban***[1] hay?" The informants were allowed to give as many responses as they could without interruption, and they were not asked to continue once they stopped (hereafter, this part of the preliminary interviews will be referred to as "listing requests"). Interviews were conducted without any other adults present in order to obtain independence of response. Afterwards, the same interviewees were prompted with color drawings from a field guide (Emmons 1990) and a book (Eisenberg 1989), and with specific questions about bats that were expected to be in the area; however, only those responses given without prompting are considered in this paper.[2]

Recording of Bat Natural History Accounts.—From May to July of 1998, monologues about the natural history of local mammals were elicited from 7 Matses men (Informants C–I; two from Buen Perú, two from Nuevo San Juan, two from Buenas Lomas, and one from Estirón; Figure 1) and recorded on digital minidisk. All monologues were in the Matses language (5 of the informants spoke Spanish to various levels of fluency, the other 2 were completely monolingual). To elicit the texts, informants were asked to talk about a terminal folk taxon, which was mentioned only once by the interviewer (Fleck). Informants were asked to say as much as they wanted about any topic relating to the folk taxon in question, and were not interrupted or asked to continue, regardless of the length of their monologue. Each informant was interviewed with no other adults present in order to achieve

independence of response. These recordings were subsequently transcribed and translated by Fleck and checked for accuracy with Matses speakers at Nuevo San Juan in 1999.

Bat Faunal Sampling and Taxonomic Identifications.—From May to July of 1998, Voss sampled the bat fauna within a 3-km radius of Nuevo San Juan by ground-level mistnetting and by searching for roosts (see Voss and Emmons [1996] for detailed descriptions of these inventory methods). Local habitats sampled by mistnetting included gardens and clearings around Matses houses, secondary growth (abandoned swiddens), well drained primary forest, *aguajales* (*Mauritia flexuosa* palm swamps), and river beaches. Under the forest canopy, mistnets were usually deployed in linear (tandem) arrays along existing trails or in specially cut net lanes, but right-angled or other configurations were sometimes used. Nets were opened just before dark (often when it was still light enough to read), and were tended continuously until they were closed (usually before midnight). The equipment used consisted of 2.6 × 6 m nets woven from 70 denier (d) thread, and 2.6 × 12 m nets of 50 d thread; all nets had a mesh size of 36 mm.

Bat roosts were located with and without the involvement of Matses volunteer helpers in 1998, but Voss collected all specimens (usually by shooting) and recorded data (roost location, habitat, etc.) himself. From September to November of 1999, however, 5 Matses men were paid salaries to look for bat roosts: 2 to 4 men were so employed on any given day. For the first month of the 1999 field season, the Matses did not collect bats or record data themselves, but returned to the village to lead Fleck to the roosts where he shot specimens and took notes. Subsequently, Matses assistants both collected specimens and recorded data themselves, and then brought the specimens to Fleck, who identified, catalogued and preserved them. Matses collectors recorded their observations in field notebooks (Figure 2), which Fleck later translated.

All mistnetted and shot bats were provisionally identified to species in the field using published sources (e.g., Emmons 1997) and manuscript keys. Up to 20 voucher specimens were preserved for every species encountered, including any individual whose identification was deemed problematic by Voss or Fleck. Their field identifications were subsequently confirmed by Simmons, who examined all preserved bat voucher material from this project. Duplicate sets of vouchers are deposited in the Museo de Historia Natural de la Universidad Nacional Mayor de San Marcos (Lima) and in the American Museum of Natural History (New York).

Elicitation of Bat Names.—During the 1998 field season, mistnetting provided an ample supply of freshly-killed bats for eliciting Matses bat names. All bat name elicitation was conducted at Nuevo San Juan by Fleck. The bats were presented to the Matses (Informants E–G and J–O) in a plastic tray containing specimens of several species (including multiple individuals of most species), each tagged with an identification number. The Matses were asked, sometimes one person at a time and sometimes in groups, to name the bats in the tray. The Matses were encouraged to inspect the bats by turning them over and stretching out their wings, and thus often gave more than one response, with second or third responses motivated by the discovery of white wing tips, lines on the bat's back, etc. All responses

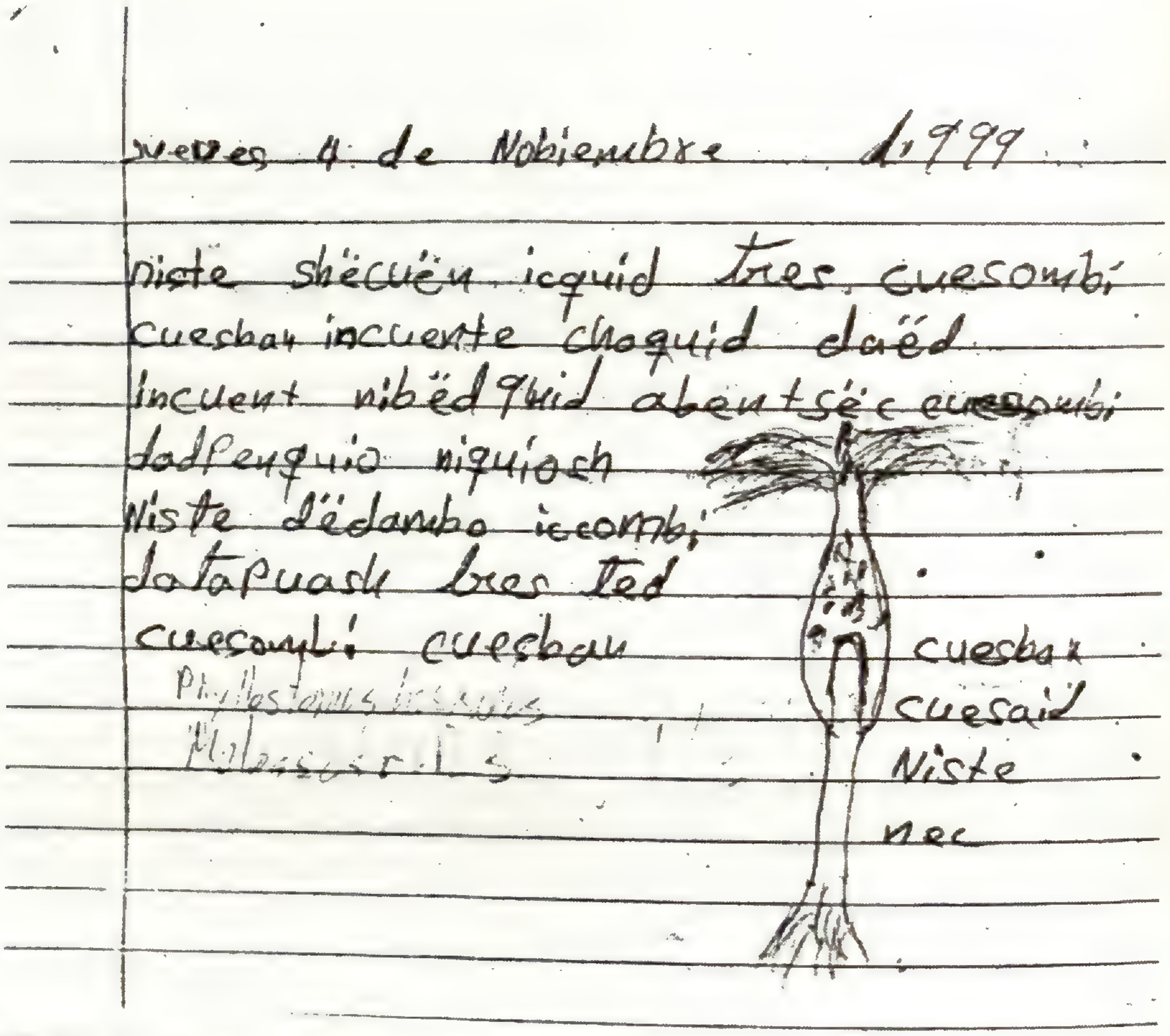


FIGURE 2.—One page from a Matses research assistant's field notebook, describing the roost where he collected two Mastiff Bats (*Molossus rufus*) and one Spear-nosed Bat (*Phyllostomus hastatus*). Translation: 'Tuesday, November 4, 1999. I killed three ***niste*** palm [*Iriartea deltoidea*] hole dwelling ones. I killed two tailed bats and one tailless one. Many flew off. I didn't chop the ***niste*** palm down, after having made a bridge to the trunk [with a log]. I killed a total of three bats.' To right of drawing: 'The ***niste*** palm of the killed bats.'

were recorded along with the name of the informant and the identification number of the specimen referred to.

During the first month of the 1999 field season, while accompanying Matses assistants to collect bats at roosts they had found, Fleck recorded Matses bat names along with relevant roost data for all bats collected. Bat names were elicited at the roost site as the Matses inspected the shot bats. When the Matses started to collect the bats on their own, they were asked to record a name for the bat along with the other relevant roost data. Back at the village, Fleck often discussed (in Matses) the bats with the Matses man who collected them and with any other Matses that were present, and recorded terms and phrases that the Matses used to refer to the bats.

Linguistic Analysis of Bat Terminology.—Matses responses (from listing requests and name elicitations) were subjected to morpho-syntactic tests to distinguish lexicalized terms (endocentric expressions; henceforth "lexemes") from *ad hoc* descriptive phrases (exocentric expressions). These tests involved modifying responses

linguistically and checking with speakers for grammaticality and, if grammatical, recording the meaning of the modified phrases. Morpho-syntactic tests were applied both at the time of the name elicitation with the dead bats at hand, and at other times using the entire inventory of responses. The general principle of Matses grammar upon which these tests were based is that lexicalized polymorphemic names are treated grammatically as noun roots while descriptive phrases are not. Thus, lexicalized phrases cannot have any linguistic material (affixes, clitics or words) inserted between the units in the word/phrase, and modifiers modify the whole lexeme, rather than just one component. Descriptive phrases, by contrast, can have linguistic material inserted between the morphemes, and the scope of the modifiers can be restricted to the word in the phrase that directly precedes them.

RESULTS

Listing Requests.—The 5 interviewees responded to the question of how many types of bats they knew about with a mean of 16.6 responses (ranging from 8 to 22), totaling 83 cumulative responses distributed among 43 different bat descriptive terms. Table 1 is a compilation of all the responses to the listing requests, categorized with respect to the information content of the phrase. Responses referring to morphology (coloration, size, distinctive body part, etc.) were about twice as common as those describing behavior (diet, roosting habits, etc.). None of the responses was given by all 5 interviewees, but many responses were given by 4 of the 5. Inspection of Table 1 reveals that several pairs of responses given by the same informant would be impossible if applied to a single referent or to a homogenous group (e.g., 'big bat' and 'small bat'; 'dark bat' and 'light-colored bat').

Recording of Bat Natural History Accounts.—The seven recorded bat natural history accounts lasted a total of 13:20 minutes, ranging from 99 seconds to 145 seconds, with a mean of 114 seconds. A list of bat natural history information given by the Matses in these interviews appears in Table 2 (see Appendix B for text translations). Interestingly, in contrast to the nature of the listing request responses (Table 1), the Matses monologues included more information about behavior than about morphology, although there was more concordance among responses referring to morphology than to behavior.

Bat Faunal Sampling and Taxonomic Identifications.—We collected a total of 503 bat specimens at Nuevo San Juan from 1998 to 1999. We mistnetted on 21 nights in 1998, deploying an average of 40.9 m of nets for 2.6 hours per night. Overall, we netted for 2,309 net-meter-hours (nmh), capturing 372 bats, of which we preserved 166 as voucher specimens. We recorded data from 24 bat roosts in 1998 and from 142 roosts in 1999, for a cumulative total of 168 recorded roosts. A total of 311 specimens were collected as roost vouchers from 1998 to 1999.

Combining bat identifications obtained by mistnetting and by searching for roosts, we documented the local occurrence of 57 species representing 33 genera in 10 higher-order Linnaean categories (families or subfamilies; Appendix A). In addition, the local occurrence of two or three other species (not observed by us)

TABLE 1.—Compilation of bat descriptive phases listed by five Matses interviewees.

Matses responses	Translation	Informant A	B	C	D	E
Names describing appearance (55 responses; 26 different phrases)						
Color						
cuesban chëshë	'black/dark bat'	A	B	C	D	
cuesban ushu	'white/light-colored bat'		B	C		E
cuesban piu	'red bat'		B	C	D	
cuesban tanun	'gray bat'		B			
cuesban bëshpiu	'yellow bat'	A	B			
cuesban chëshë-chëshë	'brown bat'			C		
cuesban piu-piumbocquid	'reddish bat'	A				
cuesban tanun-tanuquiocquid	'grayish bat'	A				
Distinctive markings						
cuesban mapiu	'red-headed bat'		B			
cuesban cabëdi	'variegated-backed bat'	A	B		D	
cuesban cadaun	'stripe-backed bat'	A	B			E
cuesban bëdi-bëdicquid	'spotted bat'	A				
Size						
cuesbanëmpi	'little bat'	A	B		D	
cuesbandapa	'big bat'	A	B			E
Color and size						
cuesban chëshëmpi	'little black bat'		B	C		E
cuseban chëshëdapa	'big black bat'		B		D	
cuesban ushumpi	'little light-colored bat'	A			D	
cuesban piumpi	'little red bat'	A				
cuesban piudapa	'big red bat'		B		D	
cuesban tanunëmpi	'little gray bat'			C		
Distinctive marking and size						
cuesban bëdimpi	'little spotted bat'		B	C	D	
cuesban tacsedëmpi	'little white-bellied bat'		B			
Distinctive body parts						
cuesban pabiatedapa	'big-eared bat'	A				
cuesban incuente choquid	'free-tailed bat'	A	B	C	D	
cuesban dëuishquedo	'fleshy-nosed bat'	A	B	C	D	
cuesban cabëdi dëuisac	'variegated-backed, long-nosed bat'		B			
Names describing natural history (28 responses; 17 different phrases)						
Feeding habits						
cuesban mani chequid	'plantain-eating bat'	A		C	D	E
cuesban muëquid pequid	'fish-eating bat'	A				
cuesban cute bacuë chequid	'dicot-tree-fruit-eating bat'				D	
cuesban bucu bacuë chequid	'*Cecropia*-tree-fruit-eating bat'	A				
cuesban chiuish bacuë chequid	'fig-fruit-eating bat'				D	E
cuesban capishto pequid	'cricket-eating bat'				D	
cuesban biush pequid	'fly/mosquito-eating bat'				D	
cuesban intac chishquid	'blood-sucking bat'	A	B	C		E
Roosting habits						
cuesban mechodo icquid	'bat that is in hollow termite nests'	A			D	
cuesban cute shëcuë icquid	'bat that is in dicot tree holes'				D	
cuesban buintad shëcuë icquid	'bat that is in hardwood tree holes'	A				
c. shëcmaucudanmës podo icquid	'bat that is in *Hyospathe* palm fronds'					E

TABLE 1.—(continued)

Matses responses	Translation	Informant A	B	C	D	E
cuesban mani pada podo icquid	'bat that is in wild banana leaves'				D	
acte cuesban	'river bat'	A	B	C	D	
acte nantan cuesban	'on-the-river bat'		B			
abuc cuesban	'high-up bat'		B			
Vocalization						
cuesban coshquequid	'bat that vocalizes saying "cosh"'			C		
Total responses given by each informant (grand total = 83; mean = 16.6)						
Total different responses = 43						

is implied by Matses descriptions of fishing bats (almost certainly *Noctilio leporinus*), vampires that feed on humans and dogs (*Desmodus rotundus*), and vampires that feed on chickens (perhaps *Diaemus youngi* and/or *Diphylla ecaudata*). The local bat fauna therefore includes a probable minimum of about 60 species.

Elicitation of Bat Names.—Elicited bat names showed much inconsistency among informants, among single informants' responses for different specimens of the same species, and even among responses of single informants for a single specimen, suggesting that none of the responses were lexicalized names, i.e., lexemes habitually used to designate a category. Interestingly, however, the responses were not completely random, exhibiting some preferences in the subset of descriptive phrases used, or, perhaps, a tendency to focus on a particular subset of morphological/behavioral characteristics (Table 3).

The most evident pattern in bat name elicitations was that all names elicited using dead bats that were mistnetted the night before were descriptive of the bat's appearance, while some names elicited at roost sites were descriptive of roosting behavior in addition to morphological properties. No names elicited with dead bats referred to feeding habits, vocalization, or other aspects of behavior. Table 3 lists all name elicitation responses for one bat family, illustrating the level of inconsistency in responses and the nature of the names in relation to whether or not the informant saw the bat's roost. This pattern indicates that characteristics of the bats other than those directly observable during elicitation were not inducible by the Matses upon inspection of bat carcasses or roosts.

When several Matses were present during name elicitation, they never argued among each other as to the "correct" name for a bat when they gave different responses. This contrasts with name elicitation for other mammalian taxa, in that there were sometimes arguments about nomenclature. For example, when a group of Matses were presented with a freshly killed specimen of *Scolomys ucayalensis*, a rarely-encountered, tiny, gray mouse, the following discussion ensued:[3]

1st man:	***yama***	***biec-quid***	***ne-e-c***
	short.tailed.opossum	be.like-Agt.Nzr	be-Npast-Indic

'It's one that is like a short-tailed opossum.'

TABLE 2.—Summary of the 7 recorded bat natural history accounts (see Appendix B for the translations of all the natural history accounts).

Type of information	Information given	Informant						
		C	D	E	F	G	H	I
diversity/abundance	there are different kinds of bats	C	D	E		G		I
	bats are numerous	C	D	E	F	G		
morphology	black/dark-colored	C		E	F	G		
	white/light-colored	C			F	G		
	red	C		E		G		
	white-chested			E				
	small	C		E	F			I
	large	C			F			I
	little and black	C				G		
	big and black	C						I
	little and white	C						
	little and gray			E				
	free tail			E	F	G		
	tiny tail		D					
	fleshy nose			E				
	long tongue			E				
	have wings		D				H	
feeding habits	eat all sort of things					G		I
	eat plantains	C	D		F	G		I
	eat only the end of the plantain						H	
	eat plantains in swiddens						H	
	eat dicot tree fruits				F	G	H	
	eat fig (*Ficus* spp.) fruits	C			F		H	I
	eat vine fruits							I
	eat *Cecropia* tree fruits							I
	eat fruits by going back and forth						H	I
	eat fruits while hanging						H	
	eat fruits in primary forest						H	
	vocalize as they eat fruits				F			
	eat roaches				F			
	eat crickets				F	G		
	catch insects on the wing				F			
	suck Matses' blood	C		E	F			
	blood doesn't coagulate after bat bite	C						
	suck dogs' blood				F			I
	bite dogs on the ear							I
	suck chickens' blood			E				
	eat at night					G	H	
roosting habits	roost in different ways			E				
	roost in hollow trees	C		E	F	G		I
	roost in hollow termite nests			E	F	G	H	I
	roost under fallen trees			E	F			
	roost between stilt roots			E				
	roost on trunks of dry trees			E				
	roost in holes in gullies	C			F			I
	roost in rolled wild banana leaves	C		E	F	G		I
	roost in *Hyospathe elegans* palm leaves	C	D					
	roost in *Attalea butyracea* palm leaves	C						
	roost in *Cecropia* tree leaves					G		
	modify leaves to make tents	C		E				

TABLE 2.—(continued)

Type of information	Information given	Informant C	D	E	F	G	H	I
	roost above rafters of houses		D					
	roost in abandoned houses							I
	roost on trees over rivers	C		E				I
	roost near sandy streams			E				
	roost near swiddens					G		
	roost high up		D					
	roost in primary forest		D					
	sleep hanging						H	
	hang upside-down						H	
	roost in groups	C						
	dirty their roosts with feces	C						
sounds	make audible vocalization	C			F		H	I
	vocalize at night	C						
	vocalize high up	C						
	make audible flapping noise	C					H	I
	[call imitations]						H	
	[flapping imitations]	C	D		F		H	
movement	fly around at night		D		F			
	do not fly around in the day	C						I
	fly high						H	
	fly over the river	C						
	always swooping by						H	
	throw down fruits as they fly by		D				H	I
activities in houses	come inside houses		D					I
	fly around inside houses	C						I
	come in houses to eat plantains		D					
	give birth inside in house roofs		D					
	leave feces inside houses	C						
	knock down arrows inside houses		D					
	vocalize inside houses	C	D					
non-natural history	inedible (dietary taboo)	C						
	bats are bad/worthless		D					
	Matses kill bats that come in houses							

old man: ***yama*** ***penquio*** ***ne-e-c*** ***tambisëmpi***
short.tailed.opossum NegEmph be-Npast-Indic rat/mouse

ne-e-c
be-Npast-Indic

'It's not a short-tailed opossum. It is a rat/mouse.'

2nd man: ***tambisëmpi-n*** ***bacuë*** ***ne-e-c***
rat/mouse-Gen offspring be-Npast-Indic

'It's a baby rat.' [lit. 'It's a rat/mouse's offspring.']

TABLE 3.—Bat name elicitations for bats of the family Emballonuridae.

Capture date	Specimen number	Informant	Naming response	Translation of response	Informant saw roost
Cormura brevirostris (Chestnut Sac-winged Bat[a])					
23 June 98	AMNH 272786	F	***cuesban chëshëmpi***	'little black bat'	no
23 June 98	AMNH 272786	L	***cuesban chëshë***	'black bat'	no
23 June 98	AMNH 272786	G	***cuesban chëshë***	'black bat'	no
2 Sep 99	AMNH 273036	F	***cuesban chëshë***	'black bat'	no
2 Sep 99	AMNH 273037	F	***cuesban chëshë***	'black bat'	no
22 Sep 99	AMNH 273108	F	***cuesban cute tëdion icquid***	'bat that is under logs'	yes
22 Sep 99	AMNH 273109	Q	***cuesban dëuishquedo***	'fleshy-nosed bat'	yes
6 Oct 99	AMNH 273132	P	***cuesban piumpi***	'little red bat'	yes
6 Oct 99	MUSM 15174	P	***cuesban piumpi***	'little red bat'	yes
6 Oct 99	MUSM 15175	P	***cuesban piumpi***	'little red bat'	yes
8 Sep 99	MUSM 15248	P	***cuesban piu***	'red bat'	yes
8 Sep 99	MUSM 15248	Q	***cuesban dëuishquedo***	'fleshy-nosed bat'	yes
9 Sep 99	AMNH 273070	F	***cuesban piu***	'red bat'	yes
22 Oct 99	MUSM 15176	L	***cuesban dëuishquedo***	'fleshy-nosed bat'	no
22 Oct 99	MUSM 15177	L	***cuesban chëshëmpi***	'little black bat' (juvenile)	no
3 Nov 99	MUSM 15178	P	***cuesban dëuishquedompi***	'little fleshy-nosed bat'	yes
Peropteryx kappleri (Greater Dog-like Bat)					
25 June 98	AMNH 272797	E	***cuesban bëshpiu***	'yellow bat'	no
11 Sep 99	AMNH 273086	F	***cuesban cute shëcuë icquid***	'bat that is in hollow logs'	yes
23 Oct 99	AMNH 273174	P	***cuesban piumpi***	'little red bat'	yes
23 Oct 99	MUSM 15244	P	***cuesban piumpi***	'little red bat'	yes
26 Oct 99	MUSM 15245	F	***cuesban dëuishquedo***	'fleshy-nosed bat'	yes
Peropteryx leucoptera (White-winged Dog-like Bat)					
23 Sep 99	MUSM 15251	F	***cuesban dëuishquedo***	'fleshy-nosed bat'	yes
26 Oct 99	AMNH 273182	G	***cuesban pësed***	'clear-winged bat'	yes
2 Nov 99	MUSM 15246	G	***cuesban pësedëmpi***	'little clear-winged bat'	yes
3 Nov 99	MUSM 15247	R	***cuesban dëuishquedo***	'fleshy-nosed bat'	yes
12 Nov 99	AMNH 273197	G	***cuesban podo ushumbocquid***	'white-winged bat'	yes

TABLE 3.—(continued)

Capture date	Specimen number	Informant	Naming response	Translation of response	Informant saw roost
Peropteryx cf. *macrotis* (Lesser Dog-like Bat)					
22 May 98	AMNH 272671	F	***cuesban bëshpiumpi***	'little yellow bat'	no
22 May 98	AMNH 272671	K	***cuesbanëmpi***	'little bat'	no
22 May 98	AMNH 272671	O	***cuesban piu***	'red bat'	yes
11 June 98	AMNH 272726	F	***cuesban piumpi***	'little red bat'	no
8 July 98	MUSM 13230	F	***cuesban dëuishquedompi***	'little fleshy-nosed bat'	no
8 July 98	MUSM 13230	F	***cuesban dëuisac***	'long-nosed bat'	no
4 Sep 99	AMNH 273042	F	***cuesban dëuishquedo***	'fleshy-nosed bat'	no
4 Sep 99	AMNH 273042	Q	***cuesban dëpuen shëcuën icquid***	'bat that is in gully holes'	yes
16 Sep 99	MUSM 15249	P	***cuesban piu***	'red bat'	yes
22 Sep 99	MUSM 15250	F	***dëpuen shëcuën diadquid c.***	'bat that hangs in gully holes'	yes
23 Sep 99	AMNH 273116	F	***cuesban dëuishquedo***	'fleshy-nosed bat'	yes
11 Oct 99	MUSM 15252	F	***cuesban acte cuitsipanën icquid***	'bat that is in stream banks'	yes
11 Oct 99	MUSM 15252	F	***cuesban dëuishquedo***	'fleshy-nosed bat'	yes
27 Oct 99	AMNH 273185	G	***cuesban dëuishquedo***	'fleshy-nosed bat'	yes
Rhynchonycteris naso (Proboscis Bat)					
25 May 98	MUSM 13248	L	***acte cuesban***	'river bat'	yes
25 May 98	MUSM 13249	L	***acte cuesban***	'river bat'	yes
25 May 98	AMNH 272684	L	***acte cuesban***	'river bat'	yes
25 May 98	AMNH 272685	L	***acte cuesban***	'river bat'	yes
7 July 98	AMNH 272852	L	***cuesbanëmpi***	'little bat'	no
12 Oct 99	AMNH 273141	L	***acte cuesban***	'river bat'	yes
12 Oct 99	MUSM 15264	L	***acte cuesban***	'river bat'	yes
14 Oct 99	AMNH 273150	F	***cuesban tanunëmpi***	'little gray bat'	no
21 Oct 99	MUSM 15266	L	***acte cuesban***	'river bat'	yes
24 Oct 99	AMNH 273175	L	***cuesbanëmpi***	'little bat'	no
24 Oct 99	AMNH 273175	F	***cuesban dëuishquedo***	'little bat'	no
26 Oct 99	MUSM 15265	F	***cuesban dëuisac***	'long-nosed bat'	no

TABLE 3.—(continued)

Capture date	Specimen number	Informant	Naming response	Translation of response	Informant saw roost
Saccopteryx bilineata (Greater Sac-winged Bat, Greater White-lined Bat)					
22 May 98	AMNH 272672	F	***cuesban cadaun***	'stripe-backed bat'	no
22 May 98	AMNH 272672	K	***cuesban cadaun chëshëmpi***	'little black stripe-backed bat'	no
22 May 98	AMNH 272672	N	***cuesban cabëdi***	'variegated-backed bat'	yes
22 May 98	AMNH 272672	O	***cuesban chëshë***	'variegated-backed bat'	yes
22 May 98	MSUM 13254	F	***cuesban chëshë***	'black bat'	no
8 July 98	AMNH 272863	F	***cuesban cadaun***	'stripe-backed bat'	no
11 Sep 99	AMNH 273082	F	***cuesban niste shëcuën icquid***	'bat that is in *Iriartea* palms'	yes
20 Sep 99	MUSM 15267	P	***cuesban cadaun***	'stripe-backed bat'	yes
20 Sep 99	AMNH 273102	P	***cuesban cadaun***	'stripe-backed bat'	yes
20 Sep 99	MUSM 15268	J	***cuesban chëshë***	'black bat'	yes
28 Sep 99	MUSM 15269	F	***cuesban cadaun***	'stripe-backed bat'	yes
30 Sep 99	AMNH 273127	F	***niste shëcuen cuesban cadaun icquid***	'stripe-backed bat that is in hollow *Iriartea* palms'	yes yes
7 Oct 99	MUSM 15270	P	***cuesban dëuishquedo***	'fleshy-nosed bat'	yes
15 Oct 99	AMNH 273152	L	***cuesban cadaun***	'stripe-backed bat'	yes
21 Oct 99	AMNH 273166	P	***cuesban chëshë cabëdi***	'black variegated-backed bat'	yes
25 Oct 99	MUSM 15271	F	***cuesban cadaun***	'stripe-backed bat'	yes
Saccopteryx leptura (Lesser Sac-winged Bat, Lesser White-lined Bat)					
10 June 98	AMNH 272722	F	***cuesbanëmpi***	'little bat'	yes
10 June 98	AMNH 272722	K	***cuesban ushu***	'light-colored bat'	yes
10 June 98	AMNH 272723	F	***cuesbanëmpi***	'little bat'	yes
10 June 98	AMNH 272723	K	***cuesban ushu***	'light-colored bat'	yes
20 Sep 99	AMNH 273101	P	***cuesban cabëdimpi***	'little variegated-backed bat'	yes
20 Sep 99	MUSM 15272	P	***cuesban cabëdimpi***	'little variegated-backed bat'	yes
20 Sep 99	AMNH 273105	P	***cuesban cabëdimpi***	'little variegated-backed bat'	yes
20 Sep 99	MUSM 15273	P	***cuesban cabëdimpi***	'little variegated-backed bat'	yes

TABLE 3.—(continued)

Capture date	Specimen number	Informant	Naming response	Translation of response	Informant saw roost
7 Oct 99	AMNH 273136	E	***cuesban dëuishquedompi***	'little fleshy-nosed bat'	yes
7 Oct 99	MUSM 15274	E	***cuesban dëuishquedompi***	'little fleshy-nosed bat'	yes
20 Oct 99	MUSM 15275	F	***cuesban cadaunmpi***	'little stripe-backed bat'	no
21 Oct 99	AMNH 273167	P	***cuesban cabëdi***	'variegated-backed bat'	yes
22 Oct 99	AMNH 273171	L	***cuesban cabëdi***	'variegated-backed bat'	yes
1 Nov 99	MUSM 15276	R	***cuesban cabëdi***	'variegated-backed bat'	yes

[a] Common names from Wilson and Cole (2000) followed by names from Reid (1997) where different.

old man:	***bacuë***	***penquio***	***ne-e-c***	***en***	***is***	***aton***	***shoma***
	offspring	Neg	be-Npast-Indic	here	look	3Gen	teat

'It's not a baby rat. Look here at its teats.' [it was a female with elongated teats, indicating it had raised a litter]

woman:	***checampi***	***ne-e-c***
	mouse.opossum	be-Npast-Indic

'It's a mouse opossum.'

old man:	***checa***	***penquio***	***ne-e-c***	***checa***	***dëuisac***
	opossum	Neg	be-Npast-Indic	opossum	long.nosed

ic-e-c	***nëid***	***dëbiate-mpi***	***ic-quid***
be-Npast-Indic	this.one	nose-Dim	have-Agt.Nzr

ne-e-c
be-Npast-Indic

'It's not an opossum; opossums have long muzzles; this is one that has a small muzzle.'

Linguistic Analysis of Bat Terminology.—All Matses responses to bat listing requests and name elicitations were synchronically analyzable and descriptive in nature, all containing the superordinate category name ***cuesban*** 'bat' modified by an enclitic, adjective, noun or relative clause. We also note (Table 3) that no responses meaning "genuine bat" or "false bat" or "similar/related to [some other named taxon]," suggesting the Matses concept of bat does not have a single prototype, and that they do not name bats that they are unfamiliar with through extension of other existing category labels (as described by Berlin 1999). Also, the term ***cuesban*** alone was never listed as a type of bat, indicating that ***cuesban*** does not have polysemous meanings (i.e., meaning both 'any bat' and 'true type of bat'), as would be expected if Matses subordinate bat categorization followed a "type-specific" nomenclature pattern (Berlin 1972). If Matses responses were lexicalized, they would all correspond to Conklin's (1962:121) "composite lexemes" and Berlin et al.'s (1973:217) "secondary lexemes," but none of the responses were identified as lexemes using morpho-syntactic tests. Rather, they were all shown to have the characteristics of *ad hoc* descriptive phrases, as indicated below.

In Matses, lexicalized names do not contain relative clauses, so those responses containing relative clauses (e.g., those ending in ***quid*** in Table 1) are clearly not names. However, other *ad hoc* descriptive phrases are often formally indistinguishable from polymorphemic names, as in example (1). But at least two syntactic tests can be used to determine if terms like those in (1) are lexicalized or not. These tests are based on the grammatical property of Matses that lexicalized complex words and phrases are treated morpho-syntactically as roots, even if the elements of the lexeme consists of more that one phonologically independent word. So, despite being a predominantly polysynthetic language (i.e., words in the language can contain many morphemes), compounds can be formed in Matses

without phonological union of the stems (as in Chinese [Anderson 1985]). The first morpho-syntactic test is based on the grammatical pattern in Matses that nominal enclitics generally occur at the end of noun phrases, but if the enclitic is part of a lexicalized name, it will not be moved to the end of the noun phrase when another element is added to the noun phrase after the head noun. For example, in (1) it is not clear whether ***-mpi*** 'Diminutive' is part of a name (***bëuimpi*** is a lexicalized name for the pygmy anteater, *Cyclopes didactylus,* a very small species of anteater) or if it is part of a descriptive phrase meaning 'small tamandua' (a tamandua is a medium-sized anteater; the species found in Amazonia is *Tamandua tetradactyla*). When an adjective is added, however, this ambiguity disappears, because the adjective must follow ***-mpi*** if ***-mpi*** is part of the lexicalized name (ex. 2), but if the utterance is a descriptive phrase, ***-mpi*** will go at the end of the noun phrase, after the adjective (ex. 3).

(1) ***bëui-mpi*** ***ne-e-c***
tamandua-Dim be-Npast-Indic

'It's a pygmy anteater' (name)
or: 'It's a small tamandua' (descriptive phrase)

(2) ***bëui-mpi*** ***chëshë*** ***ne-e-c***
tamandua-Dim black be-Npast-Indic

'It's a black pygmy anteater'
but not: *'It's a small black tamandua'

(3) ***bëui*** ***chëshë-mpi*** ***ne-e-c***
tamandua black-Dim be-Npast-Indic

'It's a small, black tamandua'
but not: *'It's a black pygmy anteater'

The second test involves the morpheme ***-mbo/-quio*** (***-mbo*** is attached to words ending with a vowel, ***-quio*** to those ending in a consonant), which may occur on stems of any open lexical class. Because it is a suffix (rather than an enclitic) its domain is the word to which it is attached, so its emphatic/augmentative meaning normally modifies only the meaning of the word to which it is attached (rather than the whole phrase). Additionally, it can normally be attached to any noun stem without restriction. But in multiple-word monolexemic phrases, like that for puma (*Puma concolor*; ex. 4), the suffix ***-mbo*** treats the whole phrase as a noun root; i.e., when the series ***bëdi piu*** refers to a puma, it is impossible to suffix ***-mbo*** to ***bëdi***, and when ***-mbo*** is suffixed to ***piu***, it affects the meaning of the whole phrase (ex. 5, first translation), but if ***bëdi piu*** is used a descriptive phrase, ***-mbo*** modifies only ***piu*** (ex. 5, second translation). Also, when ***bëdi piu*** is a lexeme, the form in (6) is impossible. Note that although the translation in (6) is unusual, it is the only possible translation for this semantically awkward but grammatically correct sentence.

(4) ***bëdi*** ***piu***
jaguar red

'puma (*Puma concolor*)'
'red/orange/yellow jaguar' (a possible, but unusual gloss)

(5) ***bëdi*** ***piu-mbo*** ***is-o-mbi***
jaguar red-Aug see-Past-1A

'I saw a true puma.'
or: 'I saw a bright red/orange/yellow jaguar.'

(6) ***bëdi-mbo*** ***piu*** ***is-o-mbi***
jaguar-Aug red see-Past-1A

'I saw a true jaguar that was red/orange/yellow.'
but not: *'I saw a true puma.'

Matses speakers rejected all attempts to modify bat listing request and naming responses as if they were lexemes, while accepting the majority of constructions consisting of the response modified as if it were a descriptive phrase. For example, when two specimens of the small, light-colored Lesser Sac-winged Bat (*Saccopteryx leptura*) were captured, one Matses named them both as ***cuesbanëmpi*** 'small bat'. Upon Fleck's attempt to refer to the lighter-colored one of the two by adding an adjective to the noun phrase as though it was a lexeme using (7), (8) was given as a correction, an expression exhibiting the properties of *ad hoc* descriptive phrases (asterisks mark rejected sentences).

(7) * ***cuesban-mpi*** ***ushu***
bat-Dim white

('light-colored small bat')

(8) ***cuesban*** ***ushu-mpi***
bat white-Dim

'small light-colored bat'

If ***cuesbanëmpi*** were a lexicalized name, we would have expected the ***-mpi*** to be inseparable from ***cuesban***. Similarly, when a specimen of the White-throated Round-eared Bat, *Tonatia silvicola,* a large, light-gray bat, was named ***cuesban tan-un*** 'gray bat,' the informant allowed the suffix ***-quio*** to be inserted within the phrase (9), and when ***-quio*** was suffixed to the adjective, only the meaning of the adjective was modified, rather than the whole phrase (10).

(9) ***cuesban-quio*** ***ushu***
bat-Aug white

'a light-colored true bat'

(10) ***cuesban*** ***tanun-quio***
bat gray-Aug

'very light-colored bat'
but not: *'true light-colored bat'

In conclusion, the results of such tests show that none of these responses possess any morpho-syntactic properties of lexicalized polymorphemic phrases; instead, all of them appear to represent *ad hoc* descriptions.

DISCUSSION

Do the Matses Recognize Bat Categories Below the Level of Order?—The failure of the polymorphemic expressions to pass the syntactic tests for lexemic status is the most compelling evidence that the Matses lexicon has but one lexicalized name for bats, ***cuesban***. The inconsistency of the naming exercises using dead bats also supports the conclusion that there is only one Matses lexeme for bats. As suggested by Berlin et al. (1974:51), an important clue for determining the lexemic status of an utterance is "the reliability and stability of a particular linguistic designation over time and across informants." However, it must be acknowledged, as noted by Boster et al. (1986) and Diamond (1991), that the inability to identify well-known organisms in the absence of ecological and behavioral cues is a common shortcoming of naming exercises using dead specimens. For example, female Aguaruna informants failed to identify prepared skins of the Screaming Piha (*Lipaugus vociferans*), despite its unmistakable, loud call and the common occurrence of this bird in the region (Berlin 1992). Bats are particularly subject to the limitations of eliciting names in the absence of behavioral and ecological cues, even though we used freshly-killed bats rather than stuffed specimens. Because the Matses do not generally kill bats, they do not regularly inspect dead bats as they would game animals or non-game rodents that are killed frequently in traps. Because bats are nocturnal, it is difficult to observe their morphological characteristics clearly as they feed or fly around. Similarly, roosting behavior is usually more distinctive and observable from afar than are details of coloration and external anatomy. Therefore, it would not be surprising if the Matses responses to naming experiments using dead bats varied widely even if the Matses had lexicalized names for bats. Nevertheless, the observation that responses describing roosting behavior were given only at the roost location, and all other responses were inconsistently-applied phrases describing readily apparent morphological characteristics, suggests that the inconsistency in bat naming was due to the *ad hoc* nature of responses rather than to misidentification.

Thus, the only lexeme in Matses that designates a bat category, ***cuesban***, corresponds to the scientific taxonomic rank of order (Chiroptera). From a biologist's perspective, this is gross underdifferentiation, considering that ***cuesban*** (a category that is not further subdivided into subordinate named categories) refers to >60 locally occurring scientific terminal taxa. By implication, the Matses would seem to be much less acute observers of bat diversity than are biologists. However, this conclusion seems to be contradicted by the results of bat listing requests

(Table 1), which seem to indicate that the Matses recognize bat diversity at levels corresponding to Linnaean family, subfamily, genus, and even species.

The fact that Matses informants could list many kinds of bats from memory prior to our name elicitation exercises implies that bat descriptive phrases used by the Matses are not all based on immediate perception, but reflect a learned classification of bats that exists at some psychological level. In several listed examples, a descriptive phrase could only apply to one biological species, such as ***acte cuesban*** 'river bat', and ***acte nantan cuesban*** 'on-the-river bat', two terms that clearly apply to *Rhynchonycteris naso* (the only bat commonly found roosting over rivers in Matses territory). Another example is ***cuesban nuëquid pequid*** 'fish-eating bat', which could only plausibly refer to *Noctilio leporinus*. Similarly, only bats of the genus *Thyroptera* (Disk-winged Bats) roost in new, rolled-up wild banana leaves, so the expression, ***cuesban mani pada podon icquid*** 'bat that is in wild banana leaves', almost certainly refers to members of this genus. Although the Matses do not seem to know that there is more than one kind of vampire, the frequently listed expression, ***cuesban intac chishquid*** 'blood-sucking bat', reflects knowledge that there is a subset of bats that consume blood (members of the phyllostomid subfamily Desmodontinae). Similarly, the phrase ***cuesban dëuishquedo*** 'fleshy-nosed bat', could only appropriately apply to bats of the family Emballonuridae because the descriptive term ***dëuishquedo*** is otherwise only used to talk about the tapir's strikingly similar proboscis. (Indeed, in naming exercises, the phrase ***cuesban dëuishquedo*** was never a response for any bats belonging to biological taxa other than Emballonuridae.)

Lists such as those in Table 1 reveal a detailed knowledge about variation in bat natural history, but do not necessarily imply that the Matses conceive any categories beyond the level labeled by ***cuesban***. Because all categories in any context necessarily contain some variation in traits among members, the question here is: (i) do the Matses simply recognize variation in bat morphology and behavior, attributing the variation to single individuals exhibiting the whole range of characteristics at different times, or to individuals within the same population displaying any of these characteristics idiosyncratically; or (ii) do they actually recognize discontinuities (and multiple prototypes) within the category of ***cuesban,*** and attribute them to separate subcategories? One way to answer this question is to consider whether the Matses recognize multiple consistently co-varying morphological and behavioral traits associated with groups of bats that are referred to with particular descriptive phrases, thus pointing to the existence of natural categories[4] within ***cuesban***.

For comparison, let us consider Matses classification of dogs. The dogs with which the Matses are familiar, their hunting dogs, are thoroughly interbred, so there are no discontinuous breeds. Nevertheless, the Matses recognize variation in coloration, adult size, and hunting abilities of dogs, and they frequently use descriptive expressions like ***opa piu*** 'yellow dog', ***opampi*** 'little dog', ***opa bëdi-bëdicquid*** 'spotted/variegated dog', and ***opa nëishamë tsibanquid*** 'dog that chases tapirs' (the ultimate accolade of a fearless hunting dog). The Matses know dogs very well, seeing this variation manifested among littermates, and so they do not seem to consider these dogs to be different in kind, nor any of these characteristics to be systematically associated with one another. Nevertheless, Matses speakers

provided lists of descriptive phrases for dogs comparable to those in Table 1. Therefore, listing exercises alone cannot distinguish between the recognition of natural categories on the one hand and of individual variation on the other.

Recorded natural history monologues, however seem to provide unambiguous evidence that the Matses recognize natural categories of ***cuesban***.[5] For example, in (F19; the letter represents the informant, the number is the sentence number in the text; see Appendix B for the full texts), the use of the collective marker ***-bo*** implies that the bats being mentioned are thought of as a group, as opposed to singular referents, whereas in (E03) this seems to be mentioned explicitly—without reduplication of the root, this word would mean 'another (kind)', but with reduplication its literal translation is something like 'another-and-another kind'. In fact, 5 of the 7 informants explicitly stated that there were different kinds of bats and enumerated them in their monologues.

F19	***nua-mbo***	***cuesban***	***ic-nuc-bi***	***utsi-bo***	***ania-tsëc***
	large-Aug	bat	be-while:Diff.Ref-Emph	other-Coll	small-Dim

tsad-quid	***cuesban***	***ne-e-c***	
be:Pl-Agt.Nzr	bat	be-Npast-Indic	

'Bats are ones that while some bats are large, other (groups) are small.'

E03	***cuesban***	***utsi-utsi-ec-quid***			***cuesban***
	bat	other-(redup=Distr)-Advzr:Intr-Agt.Nzr			bat

ic-e-c	***incuente***	***cho-quid***	***cuesban***	***dëbiate***
be-Npast-Indic	tail	have-Agt.Nzr	bat	nose

dë-uishque-to-aid	***cuesban***	***shidiadquid***	***ushu-mbo***	***ic-quid***
nose-move-Incho-Pat.Nzr	bat	chest	white-Aug	be-Hab

cuesban	***chëshë***
bat	black

'There are different types of bats: tailed bats, fleshy-nosed bats, white-chested bats, black bats.'

Additional examples provide compelling evidence that at least some bat categories recognized by the Matses are natural in the sense of being based on multiple shared characteristics. For example, sentence (I17) describes a category of bat that is defined by both size and coloration. Other kinds of bats are described as sharing morphological and behavioral traits, such as size and roost type (F20), size, color and roosting location (E15–16), size, coloration, roosting location and roost type (G07–08), size and vocalization (I18), size and feeding habits (E17), distinctive body part and feeding habits (D08), and roost type, circadian activity, size and roosting location (D11–12).

I17 ***cuesban-dapa*** ***utsi*** ***ic-e-c*** ***chëshë-mbo-quid*** ***nua***
bat-big other be-Npast-Indic black-Aug-Agt.Nzr large
ic-quid
be-Agt.Nzr

'There is another big bat, a very dark-colored one, a big one.'

F20 ***utsi*** ***bëpucte*** ***podo*** ***an-diad-tsëc-ec*** ***ush-quid***
other leaf leaf inside-hang-Dim-while:S/A>S sleep-Hab

'Other little ones sleep hanging inside monocot leaves [rolled-up new banana and wild banana leaves].'

E15 ***pictsëc-quid-mpi-mbo*** ***ic-quid*** ***aid-bi-en*** ***acte*** ***nantan***
small-Agt.Nzr-Dim-Aug be-Agt.Nzr that-Emph-Focus river on
ic-tsëc-quid
be-Dim-Hab

'One that is very small, that one lives on the river.'

E16 ***cuesban*** ***tanun-mpi*** ***acte*** ***nantan*** ***ic-tsëc-quid*** ***cuesban***
bat gray-Dim river on be-Dim-Hab bat

'(That) little, gray bat roosts over the river . . . the bat.'

G07 ***utsi-bi*** ***cuesban*** ***chëshë-mpi*** ***abuc*** ***ic-tsëc-quid***
other-Emph bat black-Dim high be-Dim-Agt.Nzr
ne-e-c
be-Npast-Indic

'Still another, a little black bat lives high up.'

G08 ***cuëte*** ***shëcuë-n*** ***ic-quid-bi-di*** ***aid*** ***ne-e-c***
dicot.tree hole-Loc be-Agt.Nzr-like-Emph that be-Npast-Indic

'It is likewise one that lives in tree hollows.'

I18 ***utsi-dapa-bi*** ***nua-mbo*** ***tsecque*** ***tsecque*** ***tsecque*** ***que-quid***
other-big-Emph large-Aug bat.call bat.call bat.call say-Agt.Nzr
cuesban-dapa ic-o-sh
bat-big be-Past-3

'There was another big bat, a very big, large bat that said, "tsecque, tsecque, tsecque".'

E17 ***cuesban*** ***piu*** ***aid*** ***intac*** ***chish-quid*** ***ne-e-c*** ***cuesban***
bat red that.one blood suck-Agt.Nzr be-Npast-Indic bat
piu
red

'A red bat, that is one that sucks blood . . . a red bat.'

D08 ***incuente*** ***cho-tsëc-ec*** ***ic-quid*** ***mani***
tail have-Dim-Advzr:Intr be-Agt.Nzr plantain

che-e-c ***que-shun*** ***cues-quid*** ***cuesban***
eat.unchewed-Npast-Indic say-after:S/A>A kill-Hab bat

'After saying, "the one that has a tiny tail eats plantains" they [Matses] kill the bats.'

D11 ***shëcmaucudanmës*** ***shapesh-n*** ***ic-quid-di*** ***cuesban***
wild.banana.species rolled.new.leaf-Loc be-Agt.Nzr-Emph bat

cho-cho-ec ***ne-e-c***
come-(redup=Iter)-Advzr:Intr be-Npast-Indic

'The same one that is in new rolled wild banana leaves is the one that keeps on coming to the house.'

D12 ***nimëduc*** ***ush-tsëc-ec***
primary.forest:Loc sleep-Dim-while:S/A>S

didique-tsëc-ash-bi ***cho-cho-e-c*** ***cuesban***
hang-Dim-after:S/A>S-Emph come-(redup=Iter)-Npast-Indic bat

'The (little) bats keep coming after sleeping hanging in the forest.'

Sentences that mentioned the association of morphological and behavioral characteristics for a category of bat were provided by 6 of the 7 informants. It should be pointed out that those monologues by Matses from Nuevo San Juan were recorded in 1998, prior to their involvement in roost searching, and the other four monologues were by Matses from other villages, who were not involved at all in bat collection or bat name elicitation. Perhaps the most convincing argument that the Matses recognize sublexical categories of ***cuesban*** is in sentences like D08 above, which indicate that the Matses behave differently in response to their categorization of bats.[6]

The finding that Matses bat categorizations have multiple characteristics associated with them allows us to formally distinguish between categories of dogs and bats using set-theoretic taxonomic criteria (Kay 1971): although a "taxonomy" is defined as always including a set of names, we can still determine if sublexemic categorizations are part of a *taxonomic structure.* In the Matses descriptions of dogs, the only time that multiple characteristics can be reliably applied in combination is when referring to a single individual. A single individual does not constitute a set, and therefore cannot be considered a taxon (i.e., there are no "non-null sets" Kay [1971: 868] below the category ***opa*** 'dog'). With bats, on the other hand, multiple characteristics apply to sets of multiple individuals. A second criterion of a taxon (a natural category in a taxonomic structure) is "strict inclusion of sets restricted to members of T" (Kay 1971: 868), i.e., "a set t_i strictly includes another set t_j just if every member of t_j is a member of t_i and there is at least one member of t_i which is not a member of t_j." Because we could consider the set labeled by Matses as ***cuesban*** to be t_i, and (for example) those bats sometimes described by

TABLE 4.—Bat descriptive phases that could be tentatively associated with a single Linnaean bat taxon (See Table 1 for translations of Matses names and Appendix A for English common names).

Matses term	Biological taxon
cuesban mapiu	*Phyllostomus hastatus* (adult males)
cuesban ushumpi	*Ectophylla macconnelli*
cuesban tanunëmpi	*Ectophylla macconnelli*
cuesban tacsedëmpi	*Thyroptera tricolor*
cuesban incuente choquid	Molossidae
cuesban dëuishquedo	Emballonuridae
cuesban cabëdi	*Saccopteryx* spp.
cuesban dëuisac	Glossophaginae
cuesban nuëquid pequid	*Noctilio leporinus*
cuesban intac chishquid	Desmodontinae
cuesban mechodo icquid	*Tonatia*
cuesban mani pada podo icquid	*Thyroptera*
acte cuesban	*Rhynchonycteris naso*
acte nantan cuesban	*Rhynchonycteris naso*

Matses as ***cuesban dëuishquedo*** 'fleshy nosed bats' (which correspond exclusively to the biological taxon Emballonuridae) to be t_j, and because all members that can be called ***cuesban dëuishquedo*** are included in the superordinate category ***cuesban***, and because there are other bats that are in the set labeled ***cuesban*** but not in the set describable as ***cuesban dëuishquedo***, and because we could apply this formality to several of the groupings of bats by the Matses, it seems clear that those bats that can be described by the Matses as ***cuesban dëuishquedo*** constitute a formally-definable taxon. Some recognized categories of bats, such as ***cuesbanëmpi*** 'little bats' and ***cuesban chëshë*** 'black bats' are problematic (not obviously corresponding to a scientific taxon), but many of the categories of bats described by the Matses seem to follow the same pattern as those referred to by ***cuesban dëuishquedo*** (Table 4). The fact that two categories of emballonurid bats that are sometimes referred to with the descriptive phrases ***cuesban cabëdi*** 'variegated-backed bat' (genus *Saccopteryx*) and ***acte cuesban*** 'river bat' (*Rhynchonycteris naso*) are also sometimes referred to with the phrase ***cuesban dëuishquedo*** 'fleshy nosed bats' (family Emballonuridae), could be interpreted as a hierarchy, further suggesting that there is a taxonomic structure in Matses bat classification. There does appears to be much cross-categorization in Matses bat classification, but cross indexing has been found to be a common phenomenon in folk-biological classification systems generally (Hunn 1975; Ellen 1986).

In summary, although Matses bat classification cannot be described as a perfectly taxonomic structure, there does appear to exist some such structure in at least a subset of their unnamed bat categories. The nature of this taxonomic structure may be stored in the informant's memory, or, as suggested by Randall (1976), it may be an epiphenomenon of classifying behavior; but this argument would not distinguish Matses bat classification from other described folk classification systems.

Lexemes, Linguistic Forms, and Concepts.—A semantic means of recognizing lexemes is to see if characteristics about the referent that are not deducible from the name

are inducible by speakers; i.e., the expressions should be "semantically endocentric" (Hunn 1977:26). This might seem to be an argument for the lexemic status of some of the Matses bat expressions considering that the Matses associate multiple characteristics with some bat descriptive expressions, but this would contradict the results of the morpho-syntactic tests. One solution to this paradox is to consider some responses as being intermediate between fully lexicalized names and completely *ad hoc* descriptive phrases. Such an analysis should not be objectionable if we bear in mind that the dichotomy between lexemes and descriptive phrases simply refers to opposite extremes of a continuum, with some utterances standing in between lexemes and descriptive phrases in any language. This, in fact, seems inevitable, considering that many lexemes originate diachronically from descriptive phrases, such that at any point in time some expressions will be incompletely lexicalized. (Note that this does not imply that expressions standing in the middle of this continuum must be in a transient stage, as there is no evidence to suggest that there is equilibrium only at the extremes.) Therefore, one might argue that where one draws the line between lexemes and descriptive phrases is necessarily subject to considerable arbitrariness. The intermediate status of such expressions may be realized as in several ways, including the following:

1) Sociolinguistic:
   a. Being recognized by only some members of the speech community.
   b. Being treated grammatically as lexemes by some members of a community and not by others.
   c. Being treated as lexemes only sometimes by the same speakers.
2) Grammatical:
   a. Possessing some grammatical properties of lexemes and some of descriptive phrases.
   b. Possessing grammatical, but not phonological properties of lexemes.

The intermediate nature of Matses bat descriptive terms, however, seems to have a basis that is quite different in kind from such sociolinguistic and grammatical phenomena (although some sociolinguistic variation may have been found had we interviewed women and children). This basis might be best elucidated by considering lexemes in light of the form-meaning composites of linguistic units.

Although some ethnobiologists treat linguistic forms and the concepts for which they stand as being one and the same, it is generally understood by linguists (e.g., Saussure 1915) that linguistic forms (the signifier) are only arbitrary labels for extralinguistic concepts (the signified). The latter can all be considered essentially as categories, and it is hard to deny that humans must have some mental categories that are not linguistically labeled. Therefore, when we find that none of the Matses bat terminology behave morpho-syntactically as lexemes, the implication is that the linguistic *forms* do not have the properties of lexemes. The characteristic of having multiple shared and inducible characteristics, on the other hand, is not a property of the linguistic forms, per se, but of the Matses concepts of bats. Therefore, if we consider again the continuum between lexemes and descriptive phrases in light of the different components of a lexeme, we can see why some lexemes appear to be intermediate: the linguistic forms have no properties

of lexemes, but they can be used to refer to a concept that represents a natural category. If one of these linguistic forms was habitually used to refer a bat category, then it would be a typical symbolic linguistic unit.

A symbolic linguistic unit contrasts with an index (such as the English words *that, you* and *what*) which are linguistic units consisting of forms that point to different entities/concepts at different times. Consider the following expressions in English:

(1) a. *polar bear* b. *bear*
(2) a. *that bear* b. *that*
(3) a. *big bear* b. *big one*
(4) a. *fox squirrel* b. *big squirrel*

The expressions in (1) are symbolic linguistic units, and can be considered names; i.e., (1a) and (1b) are both lexemes in English. Those in (2) are indexes rather than symbolic units in that they do not habitually refer to the same concept, but *that* is nevertheless a lexeme in English (while *that bear* is not). Those in (3) are not lexemes in English, and therefore not animal names, but these phrases behave as indexes in that they can refer to well-formed concepts (like polar bears), even though the same concepts can be referred to more precisely with the animal's name. Now consider the examples in (4). The expression *fox squirrel* is an interesting expression in American English in that it has intermediate lexemic status in two ways: i) sociolinguistic variation, and ii) sublexemic conceptual status. The sociolinguistic pattern is that some Americans, especially zoologists and naturalists, can identify fox squirrels and regularly refer to them as *fox squirrel,* while most Americans do not distinguish species of tree squirrels and do not use the term *fox squirrel.* Of those Americans who do not use the term *fox squirrel,* some may live in areas where more than one species of tree squirrel occur in sympatry (Burt and Grossenheider 1976). For example, many Texans do not distinguish tree squirrels lexically beyond the term *squirrel,* yet they have noted that there are large, orange-bellied squirrels (Eastern Fox Squirrel, *Sciurus niger*) and smaller, grayer, white-bellied squirrels (Eastern Gray Squirrel *Sciurus carolinensis*). So while it would be inaccurate to suggest that anyone who does not use the term *fox squirrel* does not recognize the category, it would also be false to suggest that *big squirrel* is a lexicalized English name for *Sciurus niger.* This situation, and Matses bat terminology, can be described in the same way: descriptive phrases are used in an indexical manner to refer to recognized sublexemic categories.

When looking for folk-biological categories, it is certainly a useful shortcut to begin by collecting names (lexemes) that refer to biological organisms, but one should not ignore the absence of necessary congruence between the language's lexicon and the underlying folk-taxonomic structure. It is intuitive that there is a difference in the cognitive status between named and unlabeled folk-biological taxa, with lexemically-labeled taxa generally possessing a larger number of shared attributes (and perhaps a better-formed gestalt image), so it does seem justified to make a distinction between named and sublexemic categories. One might even argue that a concept cannot be fully formed until it is habitually labeled by a lexeme, in which case it becomes entrenched and elaborated by being talked about in the community more efficiently, and perhaps by being contemplated more

clearly. However, it is also evident that not all named ethnobiological categories have identical conceptual status, even if they occur at the same ethnobiological rank. For example, almost all Americans are familiar with *lemming* as a biological taxon, but their concept of *lemming* is much less developed than that of *cat*. Therefore, although excluding unlabeled terminal categories is perhaps justified for purely linguistic descriptions, it is indefensible for ethnobiological studies of cognition.

Correspondence of Matses and Scientific Classification.—The issue here concerns which types of folk-biological categories should be considered relevant for comparison with Western scientific taxa. In Matses, it is possible to distinguish three types of categories:

1) Those having no lexicalized labels, and being distinguished by a single characteristic (e.g., Matses ***opa piu*** 'yellow dogs').
2) Those having no lexicalized label, but sharing multiple characteristics (e.g., the different categories of bats recognized by the Matses).
3) Those having a lexicalized name and sharing multiple characteristics (e.g., Matses ***senta*** 'uakari monkey').

Categories of type (1) are simply *ad hoc* groupings of individuals in reference to a single characteristic. Such grouping are neither natural nor habitually labeled, and therefore there is little incentive for comparing these with scientific taxa. It should be noted here that other ethnobiologists have described named categories that are distinguished by a single characteristic, a category type that we have not encountered among the Matses. These categories would be essentially the named counterparts of category type (1). For example, Bulmer and Tyler (1968:359) report that among the Karam of New Guinea, "informants variously distinguish four or five [named] sub-taxa of *jejeg* [a term corresponding to the frog species *Hyla angiana*] which, they say, contrast in colour alone, not in shape, size, call, odour, or any other feature." And Hunn (1977:51) defines varietal taxa (taxa, by his definition, being named) as "deductive subdivisions [divisions based on a single category] of continuously heterogeneous inductive taxa."

Type (3) categories are similar to scientific categories, and therefore lend themselves well to comparison with scientific taxa, but categories of type (2) are problematic because they reflect the absence of isomorphism (one-to-one correspondence) in a language's biological lexicon and its folk-biological taxonomic structure; by contrast, scientific nomenclature and taxonomic structure are, in principle at least, isomorphic. One approach for dealing with categories of type (2) is to consider lexicalized labeling a defining property of subordinate ethnobiological categories (as in Berlin et al. 1973), thereby judging named terminal taxa as the only relevant type of terminal categories. However, if one claims to be comparing folk *classification* to scientific classification, then it is unacceptable to exclude any part of the existing folk-biological taxonomic structure. If lexemic labeling is used to determine what categories are folk taxa, then in the end the comparison is simply of a language's biological lexicon with Western scientific taxonomic labels.

Rather than constructing a criterial definition of "folk-biological taxon" with

linguistic labeling as a necessary condition, one could describe the concept of "folk-biological taxon" as itself exhibiting prototype category structure, with prototypical taxa possessing the attribute of being named, and less prototypical taxa, such as type (2) categories, as lacking that attribute. Thus, one would expect prototypical taxa like "folk generics" (Berlin 1972), "folk speciemes" (Bulmer 1970), and "generic species" (Atran 1999) to be named (the most prototypical possessing monomorphemic names), and less prototypical taxa, like those of "intermediate," "folk varietal" and "folk specific" ranks (Berlin 1992) to sometimes be named (often with polymorphemic names) and sometimes not. Factors affecting recognition of organisms (biodiversity, size, phenotypic salience, ecological salience and cultural salience [Hunn 1999]), could be correlated to the prototypicality of the folk taxon (if any) that corresponds to the biological species, rather than just to whether the species is recognized linguistically.

One way to make more effective comparisons of folk-biological with scientific classifications is to consider lexical correspondence and correspondence of taxonomic structures separately. This seems justified considering that lexicalization is necessarily a product of social consensus, whereas taxonomic structures (while they may be influenced by culture) do not require societal acceptance, and thus are free to be elaborated by individual curiosity and experience. Because biological taxa with no cultural salience but significant perceptual salience (including phenotypic discontinuity, size and ecological behavior) are likely to be recognized but not lexemically labeled,[7] it seems probable that comparisons of taxonomic structures (including covert categories at all levels) will tend to reveal greater convergence in biodiversity recognition between traditional societies and Western science than do comparisons of folk and scientific lexicons.

Implications for Biodiversity Fieldworkers.—Although lists of vernacular names applied to plants and animals by indigenous cultures sometimes provide fieldworkers with important information about local biological diversity, many problems are encountered in attempting to interpret such data (Fleck et al. 1999; Wilkie and Saridan 1999). In particular, the problem explored in this paper, lexical underdifferentiation, can result in negatively biased diversity estimates (if named terminal taxa are assumed to represent biological species), or can lead to incorrect inferences about the observational abilities of native informants (if species recognition is assumed to be encoded by names). Our results suggest that less misleading ethnobiological data can be obtained by interview methods designed to explore the covert taxonomic structure that may exist below the level of named folk species.

Clearly the Matses are more observant naturalists than their impoverished chiropteran lexicon suggests. Despite the fact that bats are apparently of no cultural significance, the Matses recognize many distinct kinds which they spontaneously discriminate by morphological and behavioral features, and there is some evidence that their knowledge of chiropteran diversity includes a shallow hierarchical structure. Although it would be misleading to suggest that such knowledge is consistently shared among all members of Matses society, neither is detailed information about bats widely shared among members of European cultures (all of which likewise label Chiroptera with a single vernacular lexeme).

Given the technical complexities of formally analyzing interview results for lexical and sublexical content, however, alternative (or additional) cross-cultural interactions that can significantly increase the efficiency of biological inventory fieldwork merit consideration. Although specimens haphazardly contributed by (or purchased from) natives are routinely preserved by inventory workers, direct participation of indigenous peoples in routine specimen collection and data recording (e.g., as described by Berlin 1984) is far less common. In the course of our continuing fieldwork at Nuevo San Juan, the Matses have responded enthusiastically to the opportunity of gainful employment as inventory participants, resulting in a larger species list than we could otherwise have obtained in the same time. For example, of the 57 species of bats currently known from vouchered records in our study area (Appendix A), 34 species were collected by Matses hunters, whose notebooks provide hitherto unrecorded aspects of roosting behavior for some taxa. Clearly, the real promise of cross-cultural contributions to biological diversity assessment cannot be realized without transcending the mere recording of local plant and animal names.

Coda.—As a final anecdote, we note that while knowledge of bat natural history may not be important to the Matses for subsistence or ritual purposes, knowledge of bat behavior can come in handy nonetheless. The following sentence, an excerpt from the winning entry in a Matses letter-writing contest at Nuevo San Juan, was meant to make a sweetheart laugh in addition to enamoring her:

cuesban-n	***inchësh-n***	***chiuish***	***bacuë***	***sin-aid***	***istuid-ash***
bat-Erg	night-Loc	fig	fruit	ripen-Pat.Nzr	find-after:S/A>S

cuishonque-an-ac-bimbo-ec	***mibi***	***ush-quin***
rejoice-Incep-Act.Nzr-like-Advzr	2	sleep-while:S/A>A

is-ash	***cuishonque-e-bi***
see-after:S/A>S	rejoice-Npast-1S

'Just as bats start vocalizing joyfully when they find ripe fig fruits at night, I rejoice when I see you in my dreams.'

NOTES

[1] The orthography used in this paper is the phonemically-based practical orthography developed by SIL personnel for Bible translation and pedagogical materials. To approximate spoken Matses, words written in this orthography should be pronounced as if reading Spanish, with the following exceptions: ***ë*** is a high central unrounded vowel ([ɨ]); ***c*** (spelled ***qu*** preceding ***e***, ***ë*** and ***i***) is pronounced as a glottal stop word-finally and preceding consonants, and as [k] elsewhere; ***d*** is pronounced as a flap between vowels, and as a [d] elsewhere; and ***ts*** should be read as an unvoiced alveolar affricate. Word-level stress is on even-numbered syllables (counting from left to right).

[2] Prompted responses were often suspect. For example, Pallas's Long-tongued Bat (*Glossophaga soricina*) illustrated in Emmons (1990: plate 6) extracting nectar from a flower with its extended tongue (a seldom-seen nocturnal activity) was called ***pinu cuesban*** 'hummingbird bat' by a Matses informant, but no Matses were ever heard to utter this phrase in the absence of the picture.

[3] Gloss line abbreviations: 1, First Person; 2, Second Person; 3, Third Person; A, Transitive Subject; Advzr, Adverbalizer; Agt, Agent; Aug, Augmentative; Coll, Collective; Diff.Ref, Different Referent; Dim, Diminutive; Distr, Distributive; Emph, Emphatic; Erg, Ergative; Gen, Genitive; Hab, Habitual; Incep, Inceptive; Incho, Inchoative; Indic, Indicative; Intent, Intention; Intr, Intransitive Agreement; Iter, Iterative; Loc, Locative; Neg, Negative; Npast, Nonpast; Nzr, Nominalizer; O, Direct Object; Pat, Patient; Pl, Plural; redup, Reduplication; S, Intransitive Subject; Tr, Transitive Agreement; >, Interclausal Argument Tracking. Parentheses in free translations enclose implied, but non-predicated information; square brackets enclose information added by Fleck to aid the reader, but not encoded linguistically.

[4] By "natural category" we mean "logically natural" or "polythetic" or "general" in the sense that the members of the set share multiple distinguishing characteristics.

[5] Another way to distinguish between recognition of natural categories and description of individual variation is asking questions about natural history to determine if the categories are characterized by multiple co-varying morphological and behavioral features. Unfortunately, such interview methodology guarantees unreliable answers due to the inherently leading nature of such questioning (Fleck 1997).

[6] Recognition of sublexemic folk-biological categories is not unique to Matses classification of bats. For example, the Matses lexically underdifferentiate species of *Geonoma* treelet palms, lumping more than half of the local *Geonoma* species (at least 8) and the only local species of the closely-related genus *Pholidostachys* in the terminal folk taxon ***chonco***. However, there is only one kind of ***chonco*** that the Matses use for making children's bows (*Geonoma maxima* (Poit.) Kunth), and the leaves of *Pholidostachys synanthera* (Mart.) H. E. Moore are used for thatch, while the leaves of none of the *Geonoma* species are used for this purpose. All palm specimens are deposited at the New York Botanical Garden with duplicates at the Herbario del Museo de Historia Natural de la Universidad Nacional Mayor de San Marcos in Lima, Peru. See Henderson et al. (1995) for palm nomenclature.

[7] By contrast, taxa with high cultural salience but low perceptual salience (e.g., domesticated breeds distinguished by minor genetic discontinuities from selective breeding) will be expected to be named, but as concepts that are non-prototypical in having few distinguishing attributes associated with them. Note that even very high cultural salience with no phenotypic salience, as with Matses dogs, does not always lead to category recognition or naming, but it can, as with Matses lexical overdifferentiation of saki monkeys, *Pithecia monachus* (Fleck et al. 2000).

ACKNOWLEDGMENTS

Work in Peru in 1998 and 1999 was funded by generous grants from the American Museum of Natural History's Center for Conservation and Biodiversity, and travel to Peru in 1994 by Fleck was provided by a Latin American Studies Program Tinker Foundation Foreign Field Research Grant. This material is based upon work conducted under a National Science Foundation Minority Graduate Fellowship, an Ohio State University Dean's Fellowship, an Ohio State University Osbourn Graduate Fellowship and a Rice University Provost's Fellowship awarded to Fleck. Stephen A. Tyler, Michel J. Achard and Spike Gildea commented on an earlier version of this paper. Sergio Solari and Victor Pacheco assisted us at the Museo de Historia Natural de la Universidad Nacional Mayor de San Marcos in Lima. Most importantly, we are indebted to the Matses for their collaboration in bat col-

lection and for sharing their knowledge and their insight. Without their hospitality and patience this study could not have been realized.

REFERENCES CITED

Anderson, Stephen R. 1985. Typological distinctions in word formation. In *Language Typology and Syntactic Description, Volume III: Grammatical Categories and The Lexicon,* ed. Timothy Shopen, pp. 3–56. Cambridge University Press, Cambridge.

Atran, Scott. 1983. Covert fragmenta and the origins of the botanical family. *Man* (n.s.) 18:51–71.

———. 1999. Itzaj Maya folkbiological taxonomy: cognitive universals and cultural particulars. In *Folkbiology,* eds. Douglas L. Medin and Scott Atran, pp. 119–203. The MIT Press, Cambridge, Massachusetts.

Berlin, Brent. 1972. Speculations on the growth of ethnobiological nomenclature. *Language in Society* 1:51–86.

———. 1973. Folk systematics in relation to biological classification and nomenclature. *Annual Review of Ecology and Systematics* 4:259–271.

———. 1974. Further notes on covert categories and folk taxonomies: a reply to Brown. *American Anthropologist* 76:327–331.

———. 1984. Contributions of Native American collectors to the ethnobotany of the Neotropics. In *Ethnobotany in the Neotropics,* eds. G. T. Prance and J. A. Kallunki, pp. 24–33. Advances in Economic Botany, vol. 1. The New York Botanical Garden, Bronx, New York.

———. 1992. *Ethnobiological Classification: Principles of Categorization of Plants and Animals in Traditional Societies.* Princeton University Press, Princeton.

———. 1999. How a folkbotanical system can be both natural and comprehensive: one Mayan Indian's view of the plant world. In *Folkbiology,* eds. Douglas L. Medin and Scott Atran, pp. 72–89. The MIT Press, Cambridge, Massachusetts.

Berlin, Brent, Dennis E. Breedlove, and Peter H. Raven. 1968. Covert categories and folk taxonomies. *American Anthropologist* 70:290–99.

———. 1973. General principles of classification and nomenclature in folk biology. *American Anthropologist* 75:214–242.

———. 1974. *Principles of Tzeltal Plant Classification: An Introduction to the Botanical Ethnography of a Mayan-speaking Community of Highland Chiapas.* Academic Press, New York.

Boster, James, Brent Berlin, and John O'Neal. 1986. The correspondence of Jivaroan to scientific ornithology. *American Anthropologist* 88:569–583.

Brown, Cecil H. 1974. Unique beginners and covert categories in folk biological taxonomies. *American Anthropologist* 76: 325–327.

Bulmer, Ralph N. H. 1970. Which came first the chicken or the egg-head? In *Échanges et communications, mélanges offerts à Claude Lévi-Strauss à l'occasion de son 60-ème anniversaire,* eds. Jean Pouillon and Pierre Maranda, pp. 1069–1091. Mouton, The Hague.

Bulmer, Ralph N. H. and J. I. Menzies. 1972. Karam classification of marsupials and rodents. *Journal of the Polynesian Society* 81:472–499.

———. 1973. Karam classification of marsupials and rodents, part 2. *Journal of the Polynesian Society* 82:86–107.

Bulmer, Ralph N. H. and Michael J. Tyler. 1968. Karam classification of frogs. *Journal of the Polynesian Society* 77:333–385.

Burt, William H. and Richard P. Gossenheider. 1976. *A Field Guide to the Mammals,* 3rd ed. Houghton Mifflin Company, Boston.

Conklin, Harold C. 1962. Lexicographical treatment of folk taxonomies. In *Problems in Lexicography,* eds. Fred W. Householder and Sol Saporta, pp. 119–141. Indiana University Research Center in Anthropology, Bloomington, Indiana, Vol. 28.

Diamond, Jared M. 1991. Interview techniques in ethnobiology. In *Man and a Half: Essays in Pacific Anthropology and Ethnobiology in Honour of Ralph Bulmer,* ed. Andrew Pawley, pp. 83–86. The Polynesian Society, Auckland.

Diamond, Jared M. and David Bishop. 1999. Ethno-ornithology of the Keteng-

ban people, Indonesian New Guinea. In *Folkbiology,* eds. Douglas L. Medin and Scott Atran, pp. 17–45. The MIT Press, Cambridge, Massachusetts.

Dwyer, Peter D. 1976. An analysis of Rofaifo mammal taxonomy. *American Ethnologist* 3:425–445.

Eisenberg, John F. 1989. *Mammals of the Neotropics, Volume 1, The Northern Neotropics: Panama, Colombia, Venezuela, Guyana, Suriname, French Guiana.* University of Chicago Press, Chicago.

Ellen, R. F. 1986. Ethnobiology, cognition and the structure of prehension: some general theoretical notes. *Journal of Ethnobiology* 6:83–98.

Emmons, Louise H. 1990. *Neotropical Rainforest Mammals: A Field Guide.* The University of Chicago Press, Chicago.

———. 1997. *Neotropical Rainforest Mammals: A Field Guide,* 2nd ed. The University of Chicago Press, Chicago.

Erikson, Philippe. 1994. Los Mayoruna. In *Guía etnográfica de la Alta Amazonía,* vol. 2, eds. Fernando Santos and Frederica Barclay, pp. 1–127. Flasco-Sede Ecuador, Quito, Ecuador.

Fleck, David W. 1997. Mammalian Diversity in Rainforest Habitats as Recognized by Matses Indians in the Peruvian Amazon. M.S. Thesis, The Ohio State University, Columbus.

Fleck, David W. and John D. Harder. 2000. Matses Indian rainforest habitat classification and mammalian diversity in Amazonian Peru. *Journal of Ethnobiology* 20:1–36.

Fleck, David W., Robert S. Voss, and James L. Patton. 1999. Biological basis of Saki (*Pithecia*) folk species recognized by the Matses Indians of Amazonian Peru. *International Journal of Primatology* 20: 1005–1027.

Handley, Charles O., Jr. 1987. New species of mammals from northern South America: fruit eating bats, genus *Artibeus* Leach. In *Studies in Neotropical Mammalogy: Essays in Honor of Philip Hershkovitz,* pp. 163–172. *Fieldiana Zoology* 39.

Hays, Terence E. 1976. An empirical method for the identification of covert categories in ethnobiology. *American Ethnologist* 3:489–507.

———. 1983. Ndumba folk biology and general principles of ethnobiological classification and nomenclature. *American Anthropologist* 85:592–611.

Henderson, Andrew, Gloria Galeano, and Rodrigo Bernal. 1995. *Field Guide to the Palms of the Americas.* Princeton University Press, Princeton.

Hunn, Eugene S. 1975. A measure of the degree of correspondence of folk to scientific biological classification. *American Ethnologist* 2:309–327.

———. 1977. *Tzeltal Folk Zoology: The Classification of Discontinuities in Nature.* Academic Press, New York.

———. 1999. Size as limiting the recognition of biodiversity in folkbiological classifications: one of four factors governing the cultural recognition of biological taxa. In *Folkbiology,* eds. Douglas L. Medin and Scott Atran, pp. 47–69. The MIT Press, Cambridge, Massachusetts.

Hunn, Eugene S. and David H. French. 1984. Alternatives to taxonomic hierarchy: the Sahaptin case. *Journal of Ethnobiology* 4:73–92.

Kay, Paul. 1971. Taxonomy and semantic contrast. *Language* 47:866–887.

Koopman, Karl F. 1993. Order Chiroptera. In *Mammal Species of the World: A Taxonomic and Geographic Reference,* 2nd ed., eds. Don E. Wilson and DeeAnn M. Reeder, pp. 137–241. Smithsonian Institution Press, Washington D.C.

Marengo Orsini, José. 1983. Estudio agroclimático en la zona de Jenaro Herrera (Requena, Loreto) y climático en la selva baja norte del Perú. Thesis, Universidad Nacional Agraria La Molina, Lima, Peru.

Prance, G. T. 1984. Completing the inventory. In *Current Concepts in Plant Taxonomy,* eds. V. H. Heywood and D. M. Moore, pp. 365–396. Academic Press, London and Orlando.

Randall, Robert A. 1976. How tall is a taxonomic tree? Some evidence for dwarfism. *American Ethnologist* 3:543–553.

Romanoff, Stephen A. 1984. Matses Adaptations in the Peruvian Amazon. Ph.D. Dissertation, Columbia University, New York.

Reid, Fiona A. 1997. *A Field Guide to the Mammals of Central America and Southeast Mexico.* Oxford University Press, Oxford.

Saussure, Ferdinand de. 1915. *A Course in*

General Linguistics. Philosophical Library, New York.

Schultes, Richard Evans. 1986. Recognition of variability in wild plants by Indians of the northwest Amazon: an enigma. *Journal of Ethnobiology* 6: 229–238.

Simmons, Nancy B. and Robert S. Voss. 1998. The mammals of Paracou, French Guiana: a neotropical lowland rainforest fauna, part 1: bats. *Bulletin of the American Museum of Natural History* 237: 1–219.

Taylor, Paul Michael. 1984. "Covert categories" reconsidered: identifying unlabeled classes in Tobelo biological classification. *Journal of Ethnobiology* 4:105–122.

Vivar, Judith E. 1975. Los Mayoruna: en la frontera Perú-Brasil. *América indígena* 35:329–347.

Voss, Robert S. and Louise H. Emmons. 1996. Mammalian diversity in neotropical lowland rainforests: a preliminary assessment. *Bulletin of the American Museum of Natural History* 230:1–115.

Wetterer, Andrea L., Matthew V. Rockman, and Nancy B. Simmons. 2000. Phylogeny of Phyllostomid Bats (Mammalia: Chiroptera): data from diverse morphological systems, sex chromosomes, and restriction sites. *Bulletin of the American Museum of Natural History* 248:1–200.

Wilson, Don E. and F. Russell Cole. 2000. *Common Names of Mammals of the World.* Smithsonian Institution Press, Washington, D.C.

Wilkie, Peter and Amiril Saridan. 1999. The limitations of vernacular names in an inventory study, Central Kalimantan, Indonesia. *Biodiversity and Conservation* 8:1457–1467.

APPENDIX A.—List of vouchered bat identifications from Nuevo San Juan.

Family Subfamily Genus species[a]	English common names[b]
Emballonuridae	Sheath-tailed Bats
Cormura brevirostris (Wagner, 1843)	Chestnut Sac-winged Bat
Peropteryx kappleri Peters, 1867	Greater Dog-like Bat
Peropteryx leucoptera Peters, 1867	White-winged Dog-like Bat
Peropteryx cf. *macrotis* (Wagner, 1843)	Lesser Dog-like Bat
Rhynchonycteris naso (Wied-Neuwied, 1820)	Proboscis Bat
Saccopteryx bilineata (Temminck, 1838)	Greater Sac-winged Bat
Saccopteryx leptura (Schreber, 1774)	Lesser Sac-winged Bat
Noctilionidae	Bulldog Bats
Noctilio albiventris Desmarest, 1818	Lesser Bulldog Bat
Phyllostomidae	American Leaf-nosed Bats
Phyllostominae	Spear-nosed Bats
Chrotopterus auritus (Peters, 1856)	Big-eared woolly Bat
Glyphonycteris daviesi (Hill, 1964)	Davie's Big-eared Bat
Glyphonycteris sylvestris Thomas, 1896	Tri-colored Big-eared Bat
Lampronycteris brachyotis (Dobson, 1879)	Yellow-throated Big-eared Bat
Macrophyllum macrophyllum (Schinz, 1821)	Long-legged Bat
Micronycteris hirsuta (Peters, 1869)	Hairy Big-eared Bat
Micronycteris megalotis (Gray, 1842)	Little Big-eared Bat
Micronycteris microtis Miller, 1898	Common Big-eared Bat
Micronycteris minuta (Gervais, 1856)	White-bellied Big-eared Bat
Micronycteris new species	none
Mimon crenulatum (E. Geoffroy, 1810)	Striped Hairy-nosed Bat
Phylloderma stenops Peters, 1865	Pale-faced Bat
Phyllostomus elongatus (E. Geoffroy, 1810)	Lesser Spear-nosed Bat
Phyllostomus hastatus (Pallas, 1767)	Greater Spear-nosed Bat

APPENDIX A.—(continued)

Family Subfamily Genus species[a]	English common names[b]
Tonatia brasiliense (Peters, 1866)	Pygmy Round-eared Bat
Tonatia saurophila Koopman and Williams, 1951	Stripe-headed Round-eared Bat
Tonatia silvicola (d'Orbigny, 1836)	White-throated Round-eared Bat
Trachops cirrhosus (Spix, 1823)	Fringe-lipped Bat
Trinycteris nicefori (Sanborn, 1949)	Niceforo's Big-eared Bat
Glossophaginae	Nectar-feeding or Long-tongued Bats
Anoura caudifera (E. Geoffroy, 1818)	Tailed Tailless Bat [sic]
Choeroniscus minor (Peters, 1868)	Lesser Long-tongued Bat
Glossophaga soricina (Pallas, 1766)	Pallas's Long-tongued Bat
Lonchophylla mordax Thomas, 1903	Goldman's Nectar Bat
Lonchophylla thomasi J. A. Allen, 1904	Thomas's Nectar Bat
Carolliinae	Little Spear-nosed & Short-tailed Fruit Bats
Carollia brevicauda (Schinz, 1821)	Silky Short-tailed Bat
Carollia castanea H. Allen, 1890	Chestnut Short-tailed Bat
Carollia perspicillata (Linnaeus, 1758)	Seba's Short-tailed Bat
Rhinophylla fischerae Carter, 1966	Fischer's Little Fruit Bat
Rhinophylla pumilio Peters, 1865	Dwarf Little Fruit Bat
Stenodermatinae	Neotropical Fruit Bats
Artibeus anderseni Osgood, 1916	Andersen's Fruit-eating Bat
Artibeus glaucus Thomas, 1893	Silver Fruit-eating Bat
Artibeus gnomus Handley, 1987	none
Artibeus jamaicensis Leach, 1821	Jamaican Fruit-eating Bat
Artibeus lituratus (Olfers, 1818)	Great Fruit-eating Bat
Artibeus obscurus (Schinz, 1821)	Dark Fruit-eating Bat
Ectophylla macconnelli (Thomas, 1901)	Macconnell's Bat
Platyrrhinus cf. *helleri* (Peters, 1866)	Heller's Broad-nosed Bat
Platyrrhinus infuscus (Peters, 1880)	Buffy Broad-nosed Bat
Sturnira lilium (E. Geoffroy, 1810)	Little Yellow-shouldered Bat
Sturnira magna de la Torre, 1966	Greater Yellow-shouldered Bat
Uroderma bilobatum Peters, 1866	Tent-making Bat
Furipteridae	Thumbless Bats
Furipterus horrens (F. Cuvier, 1828)	Thumbless Bat
Thyropteridae	Disk-winged Bats
Thyroptera tricolor Spix, 1823	Spix's Disk-winged Bat
Vespertilionidae	Vesper Bats
Eptesicus brasiliensis (Desmarest, 1819)	Brazilian Brown Bat
Myotis albescens (E. Geoffroy, 1806)	Silver-tipped Myotis
Myotis riparius Handley, 1960	Riparian Myotis
Molossidae	Free-tailed Bats
Molossus molossus (Pallas, 1766)	Pallas's Mastiff Bat
Molossus rufus E. Geoffroy, 1805	Black Mastiff Bat
Promops centralis Thomas, 1915	Big Crested Mastiff Bat

[a] Scientific classification and nomenclature follows Koopman (1993) as modified by Simmons and Voss (1998) and Wetterer et al. (2000).

[b] Common names from Wilson and Cole (2000), Reid (1997), and Emmons (1997).

APPENDIX B.—BAT NATURAL HISTORY TEXTS

The first text includes a 3-line analysis: the first line contains the Matses language text segmented morpheme-by-morpheme, the second line contains morpheme glosses, and the third line is a free translation for the whole sentence. For the other 6 texts only the free translations are provided.

Informant F (35-year-old man; Nuevo San Juan; 27 June 1998; 1:39 min)

F01 ***cuesban*** ***chui-nu***
bat tell-Intent:1

'I'm going to tell about bats.'

F02 ***cuesban*** ***nad-quid*** ***ne-e-c***
bat do.thus-Agt.Nzr be-Npast-Indic

'Bats are ones that are like this:

F03 ***cuesban*** ***inchësh-n*** ***natia-mbo-shë*** ***mamën-an-e-c***
bat dark-Loc much-Aug-Aug laugh-Incep-Npast-Indic

'At night, bats begin laughing loudly.'

F04 ***cuesban*** ***capu-e-c*** ***inchësh-n***
bat locomote-Npast-Indic night-Loc

'Bats fly around at night.'

F05 ***cuëte*** ***bacuë*** ***pe-quid*** ***cuesban*** ***ne-e-c***
dicot.tree fruit eat-Agt.Nzr bat be-Npast-Indic

'Bats are dicot tree fruit eaters.'

F06 ***chiuish*** ***bacuë*** ***chedo*** ***pe-quid***
fig fruit etc/too eat-Hab

'They eat figs and other similar fruits.'

F07 ***adembidi*** ***capishto*** ***cucadacha*** ***chedo*** ***pe-quid*** ***cuesban***
likewise:Tr cricket cockroach etc/too eat-Agt.Nzr bat

ne-e-c
be-Npast-Indic

'Likewise, they are ones that eat crickets, cockroaches, etc.'

F08 ***adembidi*** ***cuesban*** ***cuëte*** ***shëcuë-n*** ***ush-quid***
likewise:Tr bat dicot.tree hole-Loc sleep-Agt.Nzr

ne-e-c
be-Npast-Indic

'Also, bats are ones that sleep in hollow trees.'

F09 ***mechodo*** ***shëcuë-n*** ***ush-ash-bi*** ***cute*** ***shëcuë-n***
termite.nest hole-Loc sleep-after:S/A>S-Emph dicot.tree hole-Loc

ush-ash ***dëpuen*** ***shëcuë-n*** ***ush-ash***
sleep-after:S/A>S stream.headwaters hole-Loc sleep-after:S/A>S

que-quid ***cuesban*** ***ne-e-c***
do-Agt.Nzr bat be-Npast-Indic

'Bats are ones that sleep in termite nests, in hollow trees, or in holes in gullies.'

F10 ***badiad-n*** ***capu-esa*** ***cuesban*** ***ne-e-c***
day.time-Loc locomote-Neg.A.Nzr bat be-Npast-Indic

'Bats are ones that do not fly around in the day time.'

F11 ***inchësh-n-uid-bi*** ***cuesban*** ***mamën-an-ec***
dark-Loc-only-Emph bat laugh-Incep-while:S/A>S

capu-e-c
locomote-Npast-Indic

'Bats fly around laughing only at night.'

F12 ***cuëte*** ***bacuë*** ***pe-ec*** ***cuishonque-e-c***
dicot.tree fruit eat-while:S/A>S rejoice-Npast-Indic

'They vocalize happily as they eat dicot tree fruits.'

F13 ***ad-quid*** ***cuesban*** ***ne-e-c***
do.thus-Agt.Nzr bat be-Npast-Indic

'Bats are ones that do like that.'

F14 ***cuesban*** ***mani*** ***che-quid*** ***ne-e-c***
bat plantain eat.unchewed-Agt.Nzr be-Npast-Indic

'Bats are plantain eaters.'

F15 ***adecbidi*** ***matses-n*** ***intac*** ***chish-quid*** ***ne-e-c***
likewise:Intr Matses-Gen blood suck-Agt.Nzr be-Npast-Indic

opa-n ***intac*** ***chedo***
dog-Gen blood etc/too

'Also, bats are ones that suck Matses' blood, dogs' blood, too.'

F16 ***cuesban*** ***utsi-utsi-ec*** ***ic-e-c***
bat other-(redup=Distr)-Advzr:Intr be-Npast-Indic

'There are different kinds of bats.'

F17 ***ushu-mbo*** ***ic-ash-bi*** ***chëshë-mbo*** ***ic-ash-bi***
white-Aug be-after:S/A>S-Emph black-Aug be-after:S/A>S-Emph

incuente ***cho-quid*** ***ic-e-c*** ***cuesban*** ***ic-quid***
tail have-Agt.Nzr be-Npast-Indic bat be-Agt.Nzr

ne-e-c
be-Npast-Indic

'Bats are light-colored, black or free-tailed.'

F18 ***cuëte*** ***shëcuë-n*** ***ic-e-c*** ***cuesban***
dicot.tree hole-Loc be-Npast-Indic bat

ad-ash-bi ***mechodo*** ***shëcuë-n***
do.thus-after:S/A>S-Emph termite.nest hole-Loc

'Bats are in hollow dicot trees; also in hollow termite nests.'

F19 ***nua-mbo*** ***cuesban*** ***ic-nuc-bi*** ***utsi-bo*** ***ania-tsëc***
large-Aug bat be-while:Diff.Ref-Emph other-Coll small-Dim

tsad-quid ***cuesban*** ***ne-e-c***
be:Pl-Agt.Nzr bat be-Npast-Indic

'Bats are ones that while some bats are large, other (groups of bats) are small.'

F20 ***utsi*** ***bëpucte*** ***podo*** ***an-diad-tsëc-ec*** ***ush-quid***
other leaf leaf inside-hang-Dim-while:S/A>S sleep-Hab

'Other little ones sleep hanging inside dicot leaves [rolled-up new banana and wild banana leaves].'

F21 ***utsi-bi*** ***cuëte*** ***da-diad-tsëc-ec***
other-Emph dicot.tree trunk-hang-Dim-while:S/A>S

ush-e-c ***cuëte*** ***tëdion***
sleep-Npast-Indic dicot.tree below

'Still other (small ones) sleep hanging onto the trunk of a tree, on the underside of the [fallen] tree.'

F22 ***cuëte*** ***chimeshad-aid*** ***tëdion*** ***diad-tsëc-ec***
dicot.tree fall.over-Pat.Nzr below hang-Dim-while:S/A>S

ush-quid ***cuesban*** ***ne-e-c***
sleep-Agt.Nzr bat be-Npast-Indic

'[Those] little bats are ones that sleep hanging on the underside of fallen trees.'

Informant G (30-year-old man; Buenas Lomas; 3 July 1998; 1:47 min)

I'm going to tell about bats next. Bats are ones that eat their food, little soft fruits, as they fly around at night. That is how the bats that live in termite nests eat. Another bat, the one that has a tail, also eats like that. That same one sleeps in hollows/holes. That one is one that is inside hollow trees. Still another, a little black bat lives high up. It is likewise one that lives in tree hollows. Bats eat all sorts of things. They eat plantains and things like that, dicot tree fruits, crickets. They eat those at night after grabbing them [the crickets]. They are ones that eat like that. Another bat itself makes a tent from the leaf of wild banana plant and hangs inside. Bats are ones that hang inside like that. Bats exist in different varieties: light-colored bats, red bats, black bats. That's how many [kinds of] bats there are. There are many bats. Others I haven't seen yet. I'm only going to tell about the bats I've seen. That's really how many bats there are. Bats are ones that eat like that. Bats eat in different manners.

Informant E (40-year-old man; Nuevo San Juan; 1 July 1998; 2:25 min)

I'm going to tell about the next one, now. About bats next. There are different types of bats: tailed bats, fleshy-nosed bats, white-chested bats, black bats. On their shoulders there is a "food grabber" or something, as if it had two mouths. Bats exist in different ways. Bats sleep under trees. Bats sleep in wild banana plants. Bats sleep in termite nests. Bats sleep under buttress roots. Bats hang on the trunks of very dry trees. Other bats are under big [fallen] trees where the tree is twisted. Also, others are in big hollows, in big hollows of big ***tëmpa*** trees. There are very, very many (kinds of) bats. Bats are of many different types. One that is very small, that one lives on the river. (That) little, gray bat roosts over the river . . . the bat. A red bat, that is one that sucks blood . . . a red bat. They suck chickens' blood, Matses' too. Bats are like that. Bats exist in truly many different varieties. There are many bats. Bats are ones that are really like that. Bats are ones that you can't say all the places where they sleep. They each sleep in different places. After Matses see how they've made (their nests), they make their nest further away. When people leave, they return again. After making holes in a *Cecropia* leaf, the bats sleep. Where there is a good, dry dead *Cecropia* leaf, the bat sleeps, the light-colored bat. That's where the bats are. Bats are found dwelling in different ways. [I] have not seen every one yet. After catching them we would see all the bats.

Informant D (45-year-old man; Buen Perú; 6 July 1998; 1:20 min)

After not flying around in the daytime, many come out at night. Many come inside houses. After seeing ripe plantains, many bats come inside the house. And eat those. They don't go away. Many bats fly around right inside the house. Bats are ones that keep on coming to the same place, leaving feces right where they eat plantains, many! After saying, "the one that has a tiny tail eats plantains," they kill the bats. Bats are ones that do like that. All of them fly around outdoors and elsewhere. The same one that is in new rolled wild banana leaves is the one

that keeps on coming to the house. The (little) bats keep coming after sleeping hanging in the forest. At the top horizontal roof pole . . . after entering into [the space above] the top roof pole, bats give birth right there and get used to living there. That little bat calls out right from there [the top roof pole]. Bats are numerous ones. There are many bats. Bats are inedible ones. Bats are little ones that are all wing.

Informant C (40-year-old man; Buen Perú; 12 July 1998; 2:11 min)

(And now), bats. Bats are found in places like this: In holes in stream headwater gullies and in ***budëd*** palm [*Attalea butyracea*] leaves on the tip where it is not pinnately divided. After biting the ***budëd*** [*Attalea butyracea*] palm frond while hanging onto the frond, after biting the frond [to shape it into a tent], that one hangs inside. Bats sleep in ***shëcmaucudanmës*** palm [*Hyospathe elegans*] leaves, wild banana leaves, and in all leaves. Bats are ones that are like that. Bats want to bite Matses. People who are bitten by bats . . . after the bat bites them, their blood doesn't heal [i.e., it doesn't coagulate]. Bats are worthless ones. Inedible ones. They fly around at night. They eat plantains that Matses have hung up (in their houses). Bats are ones that want ripened plantains. Large bats fly around everywhere at night. Others fly around very high up. Another [is] extremely large. Bats call out saying "tsecque." There are many bats: little black bats, light-colored bats. Another small one hangs on trees on the big river. Bats are under [fallen] trees and places like that. Bats fly around at dusk. Bats laugh happily at night. After grabbing fig fruits, as they come flying by, they drop fruits down at house roofs. The bats throw fruits at the house so people will think, "a demon is hitting the house throwing things." Bat are ones that do like that. There are different types of bats: black bats and others, red bats, little white bats, black bats, big black bats. Bats vocalize a lot. Big bats fly by making noise with their wings. Others (sound) like a fletched arrow passing by. Bats are ones that are always flying by.

Informant H (55-year-old man; Estirón; 28 July 1998; 1:48 min)

There is another one that is like this, another winged one called "bat." They fly around like this: [bat call and flapping imitations] at night. They fly around in groups: [bat flapping imitations]. After doing like that, many fly around. They keep on flying around there. They keep on going to pick fig fruits and similar fruits. They eat while flying, they do not eat while perching. They continually go back and forth to eat fruits of big fig trees. They drop [fruits] as they continually fly around. They continually fly around like that in groups. At night they continually eat, a lot. They also fly along the river. In the swiddens, they eat plantains and things that have been cut down, without saying, "they have hung this up to eat" [i.e., they don't care that the plantains are products of the labor of Matses, not bats]. They also eat plantains indoors while continually coming inside houses. After eating the sweet ones [fruits] that are in primary forest, they find a swidden, then they find soft [ripened] plantains that have fallen off the tree, and eat them up very quickly. While continually coming back and forth grabbing, and continually coming back and forth ripping off pieces, bats do not eat all [of the plantain].

They eat leaving part of it [i.e., wastefully, without finishing it]. They also do like that when they come in Matses houses. After flying around at night, they sleep hanging in a hollow termite nest, in a termite nest that is halfway up a tree trunk. While hanging, not straight like we sleep, but hanging only by their little feet, with their head toward the ground, bats sleep (in a group). Bats are ones that sleep like that.

Informant I (30 year-old man; Buenas Lomas; 28 July 1998; 2:10 min)

Bats. One is a big bat, another is a little bat, and still another [lives] on the river. Bats were hanging under a fallen tree that bridges a stream. There was one that was a very small one, and another was a big bat. That one [the big bat] lives in termite nests, and another in tree hollows. Bats are even in holes in the ground, too. Their food plantains. . . [incomplete sentence]. They are ***bucu*** tree [*Cecropia* spp.] fruit eaters. Bats eat all sorts of things. Bats live in holes in the ground. Bats are in new rolled leaves of wild banana plants. Bats hang in old houses, inside the house. Bats are truly plantain eaters. They strongly desire plantains. They continually carry off vine fruits. Fig fruits, bats also eat things like that, things like fig fruits. There is another big bat, a very dark-colored one, a big one. There was another big bat, a very big, large bat that said, "tsecque, tsecque, tsecque." Yet another a small bat . . . [incomplete sentence]. Bats come inside houses wanting to eat plantains. Also, they are ones that bite dogs on the ears. Bats bite dogs, ear-biting them. They come indoors. They fly around indoors. All bats fly around at night outdoors, too . . . high up. That's all.

Journal of Ethnobiology 22(1): 103–131 Summer 2002

COMPARATIVE ETHNOMYCOLOGICAL SURVEY OF THREE LOCALITIES FROM LA MALINCHE VOLCANO, MEXICO

A. MONTOYA,[a] A. ESTRADA-TORRES,[b] and J. CABALLERO[c]

[a]*Laboratorio de Sistemática, Centro de Investigaciones en Ciencias Biológicas, Universidad Autónoma de Tlaxcala, Apdo. Postal 367, Tlaxcala, C.P. 90000, Tlaxcala, México*

[b]*Laboratorio de Sistemática, Centro de Investigaciones en Ciencias Biológica, Universidad Autónoma de Tlaxcala, Apdo. Postal 183, Tlaxcala, C.P. 90000, Tlaxcala, México*

[c]*Jardín Botánico, Instituto de Biología, Universidad Nacional Autónoma de México, Apdo. Postal 70-614, México, D.F. 04510, México*

ABSTRACT.—With the objective of making a comparative ethnomycological study, we selected three communities: Ixtenco, where the population is Otomi in origin; Javier Mina, where the people are of Nahua ancestry; and Los Pilares, a community of mixed Indian and Spanish descent (mestizos). These towns are located on the slopes of the Malinche Volcano in the eastern part of the State of Tlaxcala and were visited periodically from 1988 to 1992. The information was obtained by two methods: interview and questionnaire. Journeys into the forest were made with some of the respondents. We interviewed 191 people and obtained 495 completed questionnaires. In each community, we obtained biological, ecological and phenological data, as well as information on the local people's concepts and uses of mushrooms, especially those which were considered to be edible or toxic.

Key words: ethnomycology, wild mushrooms, Otomies, La Malinche National Park, Tlaxcala.

RESUMEN.—Con el objeto de realizar un estudio etnomicológico comparativo se seleccionaron tres comunidades: Ixtenco, cuya población es de origen otomí; Javier Mina, en donde los pobladores son de ascendencia nahuatl y Los Pilares, comunidad habitada por gente mestiza. Dichas poblaciones se ubican en la parte oriental del estado de Tlaxcala al pie del Volcán La Malinche, y fueron visitadas periódicamente entre 1988 y 1992; la información se obtuvo a través de dos mecanismos: entrevistas y cuestionarios. Se realizaron salidas al bosque en compañía de algunos informantes. Se entrevistó a un total de 191 personas y se completaron 495 cuestionarios. En cada una de las comunidades se obtuvieron datos sobre la biología, ecología, fenología,las concepciones acerca de los hongos y su utilización por la gente local, principalmente de los que se consideran comestibles o tóxicos.

RÉSUMÉ.—Avec l'objectif de réaliser une étude ethnomycologique comparative, on a sélectionné trois communautés: Ixtenco, dont la population est d'origine Otomi; Javier Mina, dans laquelle les colonisateurs sont d'ascendance Nahua; et Los

Pilares, une communauté habitée par des métis (mestizos). Ces populations se trouvent dans la partie orientale de l'état de Tlaxcala, au pied du volcan La Malinche, et on été visitées périodiquement entre 1988 et 1992. L'information a été obtenue par deux mecanismes: entrevues et questionnaires. On a réalisé des sorties en forêt en compagnie de quelques informateurs. On a réalisé un total de 191 entrevues et reçu 495 questionnaires. Dans chacune des communautés données ont été obtenues sur la biologie, écologie, phénologie, idées et usages des champignons, principalement des comestibles et de ceux considérés toxiques.

INTRODUCTION

A growing interest has developed during the last decade in assessing the importance of mushrooms to Mexican people. Many studies have shown that indigenous Mexican people have a wide knowledge of the biology, ecology, phenology, nomenclature, and use of these organisms (Chacón 1988; Dubovoy 1968; Escalante 1982; Escalante and López-González 1971; Estrada-Torres and Aroche 1987; Gispert et al. 1984; González-Elizondo 1991; Guzmán 1960; Mapes et al. 1981; Martínez-Alfaro et al. 1983; Palomino-Naranjo 1992; Reygadas-Prado et al. 1995).

Mexico is a multiethnic country and is home to around fifty Indian groups (Toledo et al. 1985). In addition, the country has a great richness of mushroom species as a consequence of the wide variety of environments found in its territory. Nevertheless only a few ethnomycological studies have been completed (Villarreal and Pérez-Moreno 1989).

No study has been made on the mycological knowledge of people from the State of Tlaxcala, Mexico, but there is some evidence suggesting that the earlier Nahuas of the region knew the edible and hallucinogenic properties of some mushroom species (Muñoz-Camargo 1586). No information is available about the knowledge of the Otomi who have inhabited this area since pre-Cortesian times (Gibson 1991), though some information is available for several species of edible mushrooms which are eaten and sold in the markets of Tlaxcala (Herrera and Guzmán 1961; Estrada-Torres et al. 1991; González-Fuentes 1987; Santiago-Martínez et al. 1990; Villarreal and Pérez-Moreno 1989). Tlaxcala is one of the most culturally influential states of Mexico as a result of the hybridization of Spanish and indigenous traditions following the Conquest. Nevertheless, several communities in the territory of Tlaxcala retain their indigenous Nahua identity. People from several towns on the slopes of La Malinche volcano (known locally as Volcán La Malintzi) continue to speak Nahua and preserve their own traditions. In addition, Ixtenco is an isolated Otomi village in the west of Tlaxcala, which has had a different linguistic and cultural evolution from the rest of the Otomi communities of Central Mexico (Weitlaner 1933). Most of the inhabitants of these towns live near forest patches and collect different forest products, such as wood and mushrooms, mainly for personal use. Taking these factors into account, the purpose of our study was to compare traditional mycological knowledge of the people from three towns situated on the slopes of the Malinche Volcano, Tlaxcala.

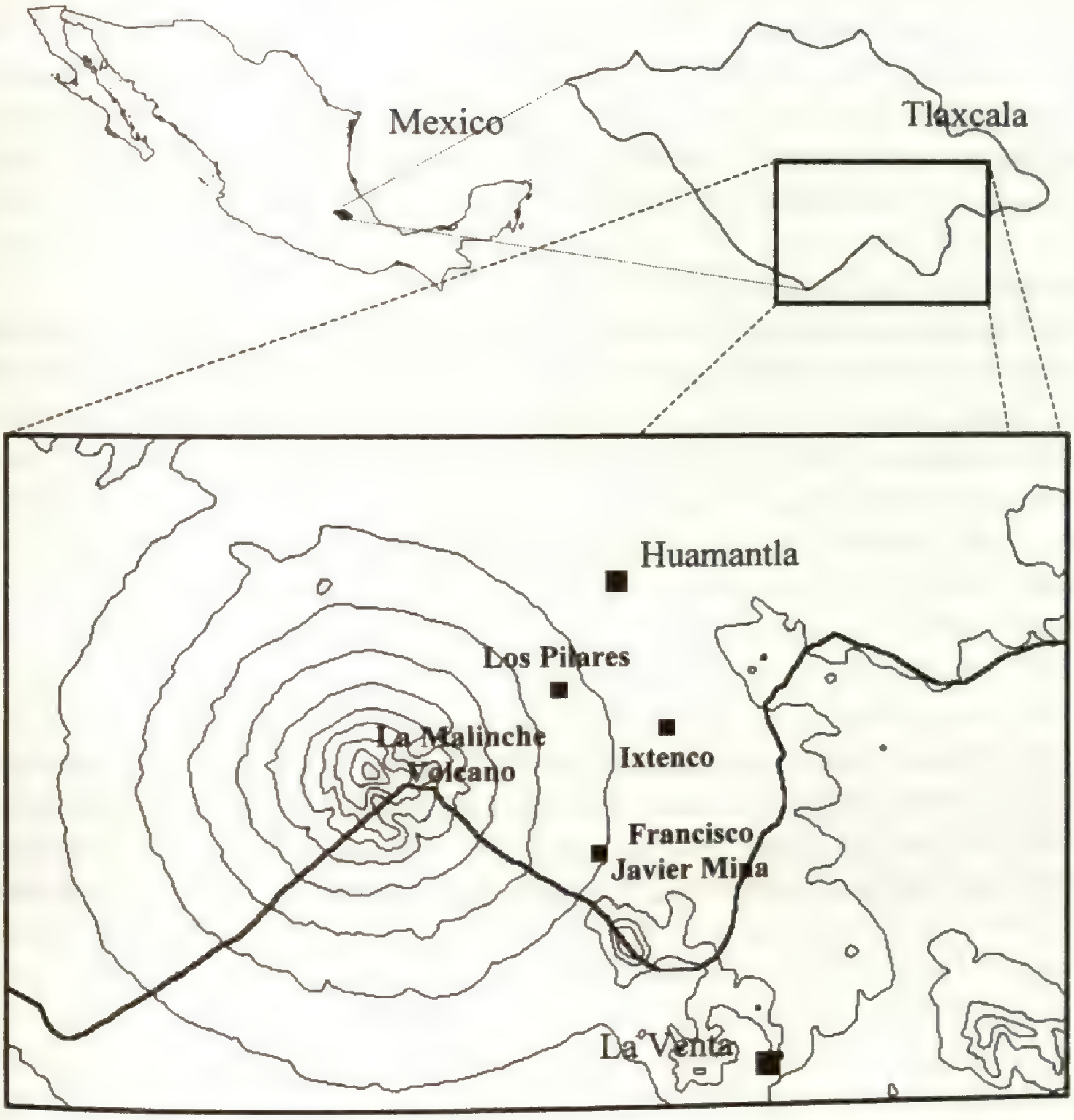


FIGURE 1.—Map showing the selected towns (Ixtenco, Javier Mina, and Los Pilares) and surrounding areas.

AREA OF STUDY

Malinche Volcano is an isolated mountain in the central part of Mexico. It lies along the border between the States of Puebla and Tlaxcala. The Malinche has the fifth highest elevation of the country, 4460 m, and was declared a national park in 1938 with a total area about 17,612 km^2 (Coordinación General de Ecología 1995). There are many small towns on the slopes of the Malinche Volcano and their inhabitants use the natural resources of the mountain in spite of it being a national park. While the municipalities of Huamantla, Ixtenco and Trinidad Sánchez Santos have their territories within the national park, the borders between them are not clearly defined. Most of the land on the Volcano is communal property, but some people own private properties. The three selected towns are located in the southeastern part of the State of Tlaxcala, and can be approached by way of Huamantla-La Venta federal road (Figure 1).

Ixtenco belongs to Ixtenco municipality and is situated at 19°14′54″ north latitude, 97°54′30″ west longitude and at an elevation of 2592 m. In 1990, Ixtenco had 5356 inhabitants: 2781 male and 2575 female. Agriculture is the main activity of the population. There were 753 Otomi speakers in that year. Ixtenco is about 8

km from the nearest forest and the people depend in various ways on forest resources. Water is the most important forest resource for the Ixtenco people, who go to the forest only to fix their old, locally-built aqueduct, which carries water from the forest to the town. Generally, they do not spend time going to the forest to collect mushrooms, plants or wood because they collect their supplies in nearby places or, more frequently, buy them in the town. These people have communal land (*ejidos*) principally (2312 ha).

The previous extent of the forest seems to have been greater than at present, according to information provided by older people, and also as it can be inferred by the forest patches found among agricultural fields belonging to Ixtenco. The habitants of Ixtenco might have made more use of forest resources in previous times and would have used them more frequently. Some people of this town say that they had never really depended on forest resources because they had farmed their own lands for a long time.

Javier Mina forms part of the municipality of Trinidad Sánchez Santos, located at 19°11′18″ north latitude, 97°55′33″ west longitude, at an elevation of 2540 m. In 1990, this municipality had 7847 inhabitants: 4022 female and 3825 male. According to the census report, only 59 people spoke Nahuatl. The main activities were agriculture, cattle production, and the sale of mushrooms; also in this case, the ownership of lands is communal and there are a few *ejidos* (487.05 ha). This town is about 4 km distant from the forest and people harvest forest resources regularly. From a mycological point of view, this fact is reflected by the number of people who collect mushrooms for eating or for selling in the markets of neighboring towns.

Los Pilares is situated in the Huamantla municipality, at 19°16′12″ north latitude, 97°56′42″ west longitude and at an elevation of 2680 m. Los Pilares had 845 inhabitants in 1990, comprising 421 males and 424 females (INEGI 1991). The main activities were cattle production, agriculture, manufacturing and sale of goat cheese, and marketing of several foodstuffs, mainly tortillas and seeds. In this town, most of the land is also communal (981.25 ha), but some people own land. The town is about 4 km distant from the forest and people use forest resources continuously; mushroom collectors sell their harvest in the market of Huamantla.

Weather.—According to the data of Huamantla Meteorological Station and using the Köppen Climatic Classification, the type of weather in the study area is $C(W_2)(w)$, subhumid with rainy season in summer (INEGI 1986); the pressure/temperature ratio is 41.9 and there is low annual variation in average monthly temperature, with fluctuations between 5° and 7°C. The annual mean temperature is 15.3°C. May is the hottest month (mean temperature = 17.7°C) and January is the coldest (mean temperature = 11°C) (García 1988).

Vegetation.—Coniferous forest is the dominant kind of vegetation. Below 3000 m we find pine forest with the following species: *Pinus leiophylla* Schl. & Chamb., *Quercus rugosa* Neé, *Q. laurina* H. & B., *Arbutus jalapensis* HBK., and *P. teocote* Schl. & Chamb. The pines *P. montezumae* Lamb. and *P. teocote* are mixed with *Alnus jorullensis* HB&K., *Salix mexicana* Seemen, *S. paradoxa* HBK., *S. oxylepis* Schn., *Buddleia parviflora* HBK., *Ribes ciliatum* H. & B., and *Abies religiosa* (HBK.) Cham. & Schl. The dominant species in the herbaceous stratum are: *Lupinus aschenbornii*

Schauer var. *furcilata, Castilleja tenuiflora* Benth., *Penstemon gentianoides* (HBK.) Poiret, *Baccharis conferta* HBK., *Eupatorium glabratum* HBK., *Asclepias ovata* Mart.& Gal., *Senecio cinerarioides* HBK., *Senecio salignus* DC., *Cirsium ehrenbergii* Sch. Bip., *Gnaphalium americanum* Mill., *Acaena elongata* L., *Alchemilla procumbens* Rose, *Prunella vulgaris* L., *Argemone platiceras* Link & Otto, and *Reseda luteola* L.

The main grasses in open areas in the *Pinus–Abies* forest, are: *Stipa ichu* (Ruíz & Pavón) Kunth., *Muhlenbergia macroura* (HBK.) Itchc., and *Eragrostis bartieri* Dar. In the agricultural fields it is possible to find scattered trees of *Buddleia cordata* HBK., *Alnus jorullensis* HB&K., *Crataegus pubescens* (HBK.) Steud., and *Prunus serotina* Her. (Acosta and Kong 1991).

Above 3000 m, the forest is dominated by *Abies religiosa,* frequently mixed with *Pinus hartwegii* Lindl. or with *P. montezumae.* In the lower stratum, some shrubs and trees are found: *Salix mexicana, S. paradoxa, Buddleia parviflora, Ribes ciliatum* H. & B., and *Prunus serotina* ssp. *capuli* (Cav.) Mc Vaugh (Acosta and Kong 1991). In the herb layer the dominant species are: *Circium ehrenbergii, Gnaphalium americanum, Taraxacum officinale* Weber, *Pernettya ciliata* (Schlecht. & Chamb.) Standl., *Halenia plantaginea* (HBK.) Griseb., *Geranium semanii* Peyr., *Prunella vulgaris, Alchemilla procumbens, Phacelia platycarpa* (Cav.) Spreng., *Habenaria limosa* (Lindl.) Hemsl., *Didymaea alsinoides* (Sch. & Chamb.) Standl., *Rumex acetosella* L., *Galium aschenbornii* Schauer., *Poa annua* L., *Plantago major* L., *Viola painteri* Rose & House, *Solanum demissum* Lindl., *Bacopa procumbens* (Mill.) Grenm., and *Eryngium carlinae* Delar. F.

Above 3500 m, the *Pinus* forest contains pure stands of *Pinus hartwegii* together with some individuals of *Alnus jorullensis* and *Abies religiosa.* The main shrubs are *Baccharis conferta, Senecio cinerarioides, S. salignus, Lupinus montanus, Salix oxilepis, Ribes ciliatum,* and *Eupatorium glabratum.* Plants of the herbaceous layer include: *Bacopa procumbens* (Mill.) Greenm., *Senecio platanifolius* Benth., *Muhlenbergia macroura, Penstemon gentianoides, Pernettya ciliata, Habenaria limosa, Milla biflora* Cav., *Castilleja scorzonerifolia* HBK., *Solanum demissum* Lindl., *Stevia monardifolia* HBK., *Pedicularis canadensis* L., *Ranunculus macranthus* Scheele., *Arenaria lycopodioides* Will. Ex. Sch., *Cyperus incompletus* (Link.) Jack., *Trifolium goniocarpum* Lojac., and *Stenanthium frigidum* (Scham. & Schlencht.) Kunth (Acosta and Kong 1991).

MATERIAL AND METHODS

The southeastern slope of the Malinche Volcano was visited every 15 days from May of 1988 to November of 1991. The people who were found collecting mushrooms were interviewed in order to find out where they came from and the purpose of their collecting (home consumption or for sale). Three towns were selected, taking into account the ethnic origin of populations: Ixtenco, an Otomi town; Javier Mina, a town inhabited by Nahua people (although we did not find any Nahuatl speakers); and Los Pilares, a small mestizo town.

Interviews included questions designed to elicit responses on several topics of mycological knowledge: conceptions about what a mushroom is, vernacular names, uses, conceptions about phenology and ecology, classification in the "cold-hot" system, methods of cooking, and poisonous mushrooms. These interviews were made with people who agreed to collaborate; we walked around each vil-

TABLE 1.—Total of interviews and questionnaires carried out in each town.

Community name	Total questionnaires	Interviews	Total population	Interviews % related to total population
Ixtenco	390	92	5980	8.0
Javier Mina	31	43	606	12.2
Los Pilares	74	56	460	28.6

lage, knocked at each door, and interviewed people who answered our questions. At least 10% of the people from Javier Mina and Los Pilares were interviewed and 8% from Ixtenco. The information obtained was recorded on audiotapes when the respondents were Otomi speakers.

Several questionnaires were prepared with the purpose of amplifying and confirming the information obtained from the interviews. These questionnaires were distributed in the schools of each town. Some students were asked to answer the questions on the spot, and other students were instructed to carry questionnaires home and request their parents or another relative to answer the questions. Responses to a few questionnaires were obtained this way. We obtained written information principally from young people (9–16 years), but interviews were held with people 17 to 90 years old. Questions in interviews and questionnaires were the same (Appendix 1). The answers to each question were grouped by categories and the data was converted to percentages. In order to compare interviews and questionnaires the information was processed independently.

Some "main respondents" were selected in each town. These respondents were people with a wide knowledge about the mushrooms from forests near their towns. Field forays for collecting mushrooms were made in the company of these persons.

The mushrooms were collected, identified and catalogued. The voucher specimens were deposited at the herbarium of Universidad Autonoma de Tlaxcala (TLXM).

RESULTS

Table 1 shows the number of interviews carried out and questionnaires completed in each town.

We elicited 121 common names of 41 edible species in the three towns (Appendix 2). Ixtenco people know 25 useful species and use 70 common names (52 in Spanish, 3 in Nahua, 2 mixed names and 13 in Otomi). Javier Mina people reported 38 species and 104 common names (90 in Spanish, 8 Nahua and 6 mixed names). Los Pilares people know 25 species and 52 common names (48 in Spanish, 2 in Nahua and 2 mixed names).

Ideas about What a Mushroom Is.—In the three communities, there are some evident differences in people's ideas regarding the nature of mushrooms. The most common idea in Javier Mina and Los Pilares is that mushrooms are different from plants and animals. People said, "nada más son hongos" (they are just mushrooms), a concept similar to that which has been established in modern mycology

(Margulis 1974). The percentage of people who gave this answer was higher than that for other concepts. Information was obtained through both questionnaires and interviews, but it was felt that the most accurate information was obtained through discussions with the interviewees. In Ixtenco, only 8% of the people interviewed said mushrooms were neither plants nor animals, but 38% considered mushrooms to be plants. Because of the use of many technical words (e.g., "cryptogamous plants") when students referred to mushrooms as plants, or to some fungi structures (scales as "hoyos ingestales," "píleo," "himenio") and some Latin names ("*Boletus satanas*," "*Amanita muscaria*") it could be supposed that young people's ideas about the nature of mushrooms has been influenced by information learned in school. Interviews showed that many people who had never attended school also considered mushrooms to be plants. Otomi people of Ixtenco use the classifier ***kho*** or ***y'kho***, which means mushroom, and they include the fungal condition athlete's foot in the category of mushroom. However they use the word ***I'm d'ga*** to refer to plants and ***fani*** to animals.

Other ideas in Javier Mina and Los Pilares are: "los hongos son agua" (the mushrooms are water) or "son producto de la tierra" (they are a product from the soil). The former view is based on the high content of water of the sporophores. For those who hold the latter view, mushrooms are considered a different kind of natural element unrelated to both plants and animals.

The value of mushrooms in the diet of the Javier Mina's people is reflected when they state, "los hongos son un alimento" (mushrooms are a kind of food).

Placement of Fungi in the Cold-Hot System.—Classifying food and other elements of the universe as "cold" or "hot" is an ancient tradition in America. It is based on the characterization of the humor and paired qualities of food as hot or cold, and dry or humid. From this point of view, food is eaten not just for nutrition, but also to treat certain kinds of illness and to promote health. For example, a person suffering from a fever should eat cold food, while someone suffering from a cold should consume hot food (Foster 1979). Some foods that are considered as hot are: meat, honey and coffee. Rice, papaya, watermelon and mushrooms, among others, are cold food. Most of the respondents of the three communities consider mushrooms to be *fríos* 'cold', either because of their high water content or the place in which they grow, frequently in wet places. Some respondents replied: "Son fríos porque crecen en el monte y ahí hace frío" (they are cold because they grow in the forest and it is cold there). Sometimes people classify mushrooms as cold because they think mushrooms produce vomiting or diarrhea when eaten in abundance or during the night. The recommendation of some women is to cook mushrooms with *epazote* (*Chenopodium ambrosioides* L.) or drink some kind of tea after eating them, because they are hot. Consequently, it is thus possible to obtain a balance of cold and hot in a mushroom meal, which is considered to be healthy.

Some people of Ixtenco and Javier Mina regard some kinds of fungi as *calientes* 'hot', *tibios* 'warm', or *templados* 'temperate'. In Javier Mina, some respondents stated that *Ustilago maydis* is hot because it grows on maize, and the stem absorbs the humidity, while the other mushrooms grow on the soil.

Morphology.—People from the three communities recognize various types of fruiting body, which are distinguished from one another by their general morphology:

mushrooms with an umbrella shape (gilled mushrooms), *pantes* and *pancitas* (boletes), *escobetas* 'brooms' (coral-like mushrooms), *bolitas o pedos de coyote* 'little balls or coyote farts' (puffballs), *chipotles* (morels), *hongos de repisa* 'shelf mushrooms' (polypores), and *papas* 'potatoes' (truffle-like mushrooms).

In the three communities, the different structures which make up a mushroom were named. In Ixtenco, both the Otomi and Spanish names were given for the following structures: cap, cuticle, gills, scales, stipe, and ring.

Only in Javier Mina were all the structures of a typical mushroom recognized; in Ixtenco and Los Pilares the volva remained unnamed. The most frequent names used to refer to the hymenium were *costillas* 'ribs', *esponja* 'sponge', and *libro* 'book'. These were mentioned in the three localities, as well as *sombrero* 'hat', *sombrilla* or *paragüas* 'umbrella', and *cabeza* 'head', which were used for the cap.

The most frequent names employed to refer to the cuticle were *pellejito* 'skin' and *tela* 'cloth'. In all three communities, the names used to refer to the stipe were the following: *tronco* 'trunk', *pata* 'foot', and *tallo* 'stalk'. In Ixtenco the term "stalk" was known by some people and was detected only through the questionnaires.

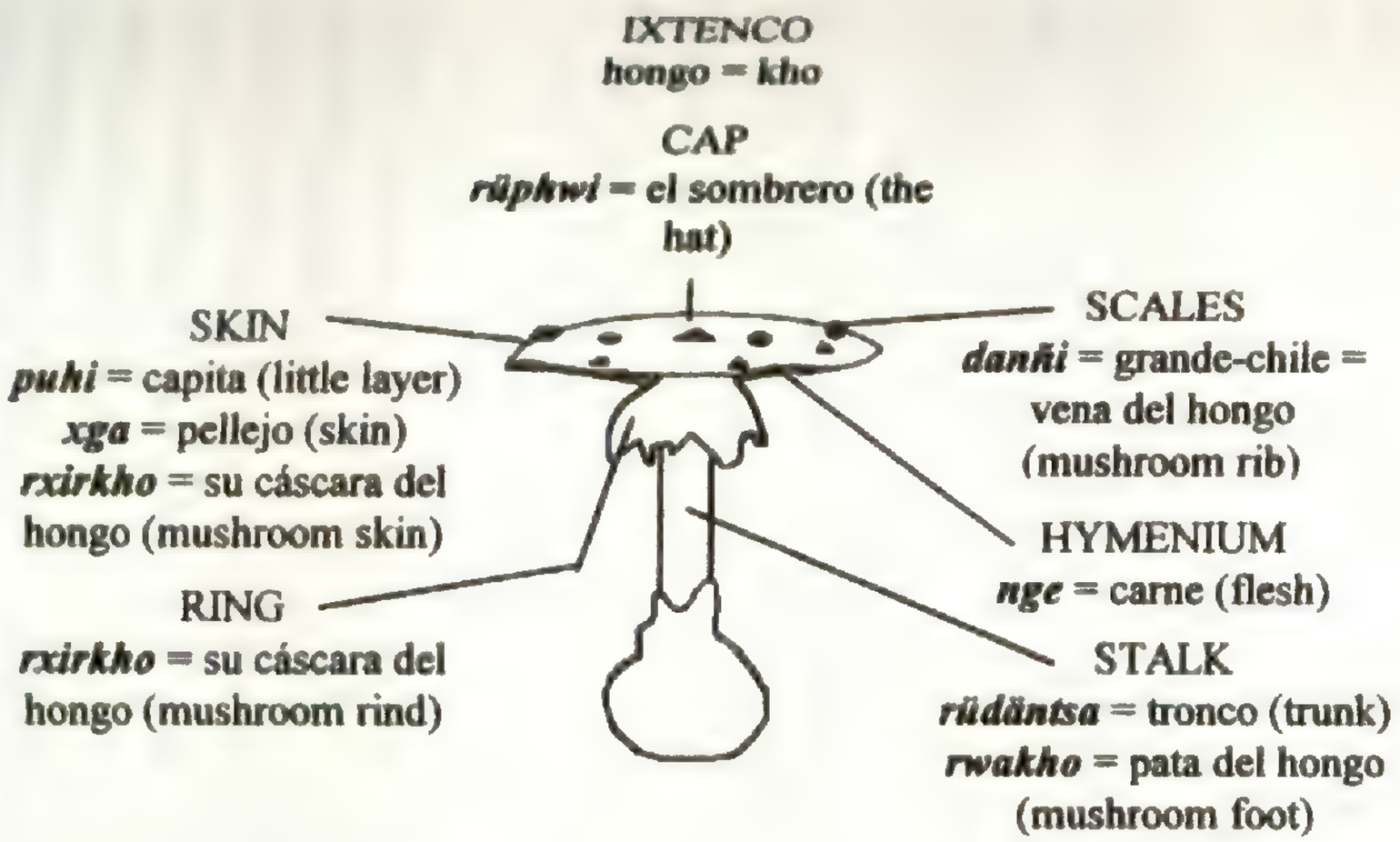
The ornamentation of the stipe is a feature commonly used by people to distinguish between edible and poisonous mushrooms, for which the following terms were used: *pata lisa* 'smooth foot' and *pata lanuda* 'woolly foot'; these coincide with the technical terms "glabrous" and "tomentose," respectively, which are used in fungal taxonomy.

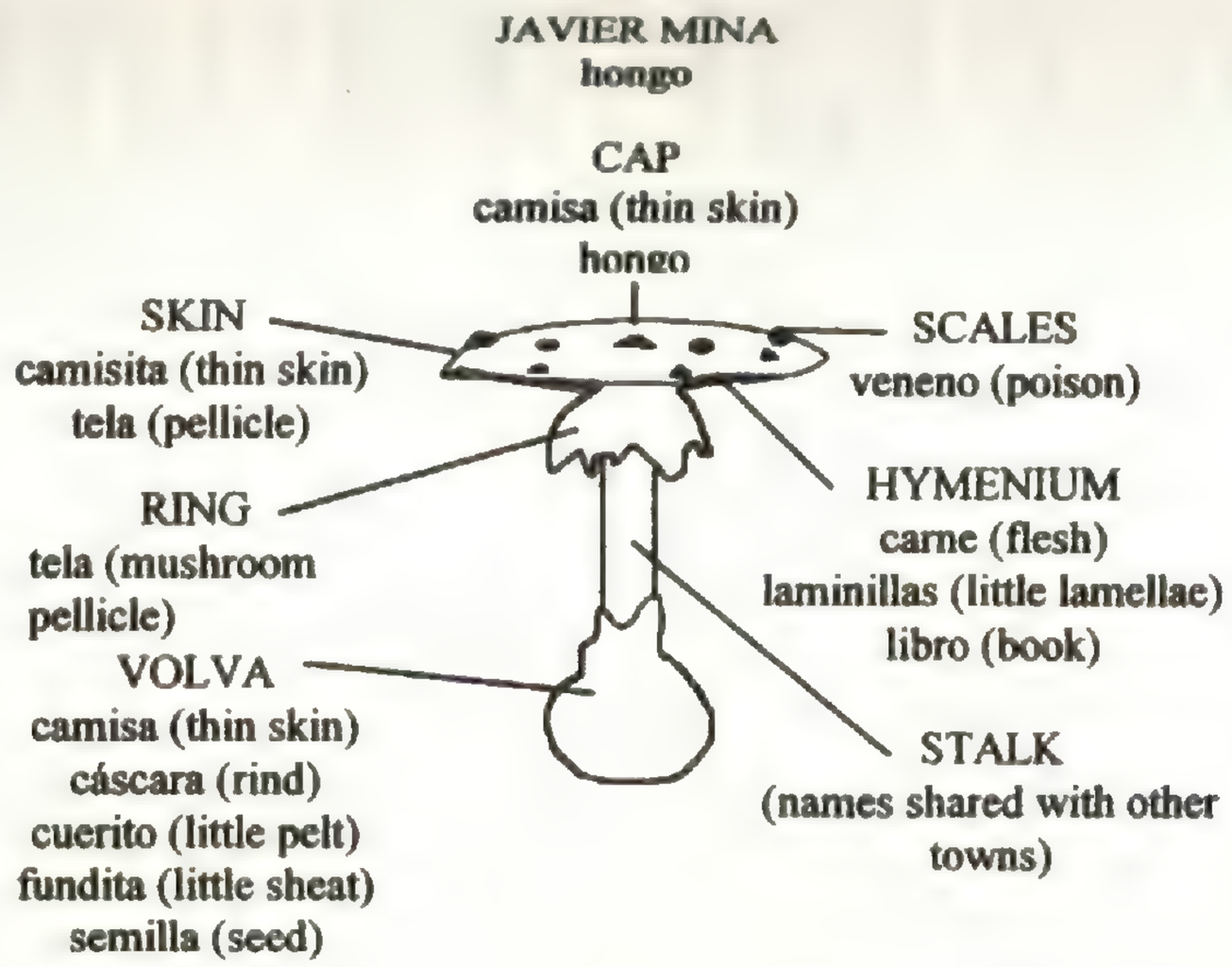
Other structures, such as scales, ring, rhizomorphs and volva, were not recognized by everyone, but people with knowledge of those mushroom parts had a common vocabulary for them. In Javier Mina, people recognized the volva, the ring, and the scales and associated these structures with the mushroom's development, because they mention that "the skin remains when the mushroom sprouts."

In Figure 2, we show terms used in each town for various structures of gilled fungi. Different terms were used to name the structures of mushrooms without gills. For example, branches from *Ramaria* are known as *bracitos* 'arms', *manitas* 'hands', and *gajitos* 'slices'; puffball scales were named *granitos* 'pimples' or *camisita* 'shirt'; to describe rhizomorphs they say: "los pedos de coyote no tienen patita, están pegados al suelo, tienen una raicita" (coyote farts don't have a foot, they are stuck to the ground, they have a little root). Some of the Spanish names used in one community are not recognized in others. Nevertheless, some of the names are used in two or in all three communities, which may be the result of increased information exchange as mushroom production has become commercialized.

Origin and Development of Mushrooms.—We have grouped the ideas about the origin of mushrooms into four categories (Table 2).

The most common idea in the three towns is that mushrooms grow only in the wild without being planted or cultivated. People said, "nacen solos," "se originan solos," or "nacen solos por la naturaleza" (they grow by themselves); "no tienen semilla ni raíz" (they have neither seeds nor roots); "la tierra es la que los produce" (the soil produces them); "brotan de la tierra" (they arise from the





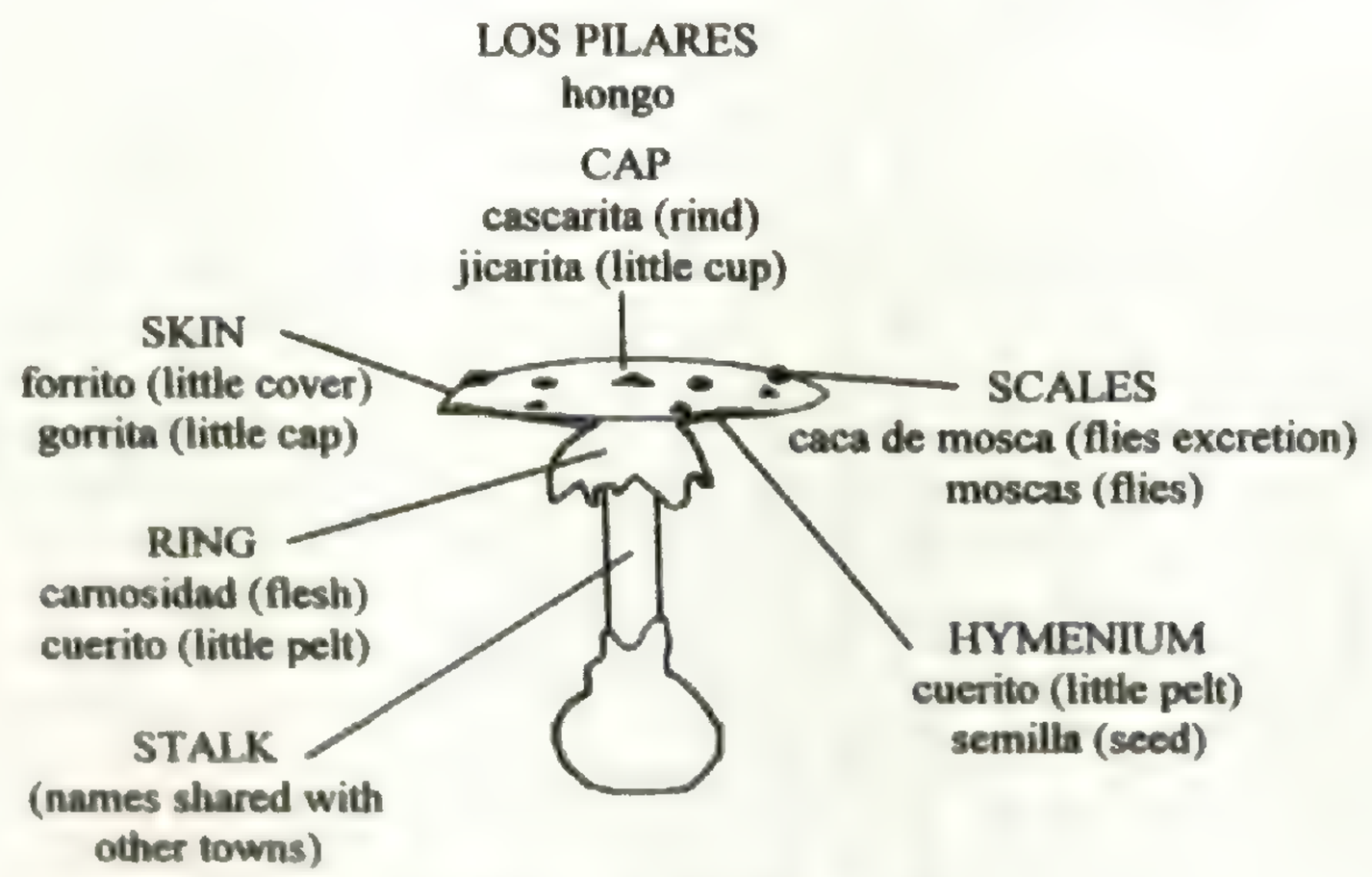


FIGURE 2.—Names for mushroom structures in Ixtenco, Javier Mina and Los Pilares.

TABLE 2.—Mushroom origin.

	Ixtenco (N = 482)	Javier Mina (N = 74)	Los Pilares (N = 130)
Wild (not being planted or cultivated)	63.6	63.8	95.4
God's will	—	1.3	—
Some fungal structures (volva or stipe base)	—	13.0	—
Spores	3.4	—	0.8
Origin unknown	33.0	24.3	3.8

Numbers indicate percentage of respondents who gave each answer. (—) This answer was not obtained in this town.

soil); "nacen por medio del agua" or "de la humedad" (they are born from moisture). These ideas probably mean that they are not planted.

A small percentage of our respondents recognized spores and sporophore structures as the mushroom's propagules. Both are called *semillas* 'seeds'. In Ixtenco and Los Pilares the respondents said, "los hongos tienen semillas, son como unas bolitas chiquitas" (mushrooms have seeds, they are like very small balls).

During field trips with people from Javier Mina, we observed that our respondents left the volva of *Amanita caesarea* and the stipe base of *Boletus pinophilus* because they consider them to be the seeds of these mushrooms. In this town people said, "el tronquito es el que produce al hongo, porque si queda enterrado vuelve a desarrollar" (the little trunk produces the mushroom because if it remains underground, mushrooms grow back).

In this community, some respondents answered that mushrooms are originated by Divine Will; they said, "nacen por la voluntad de Dios" (they grow by God's will).

People in our study area recognize some important factors in the origin and development of mushrooms. In the three communities, more than 50% of our respondents pointed to the moisture (rain) as the principal factor involved in mushroom growth, but many respondents said that *ocoshal* (*Pinus* litter), dung, or seasons of the year are also very important factors. It is interesting that many people believe fire to be a critical factor for the development of mushrooms. This idea indicates a considerable familiarity with the growth habits of some *Hebeloma* and *Lyophyllum* species, which have carbonicolous habits (Moser 1983). This accurate observation induces people to burn the forest with the purpose of increasing the production of these species. In addition, the people know that forest fires promote the production of grasses with which to feed cattle and that burning off the vegetation makes it easier to find mushrooms.

Phenology.—In the Malinche towns, the people know that the mushroom growth season is closely associated with the rainy season. They say, "si no llueve, no hay hongos" (no rain, no mushrooms). Most people agree that mushrooms fruit from May to September, with July and August being the months with highest abundance of species. However, people said, "la temporada es variable dependiendo de la precipitación" (the season is variable depending on the rains) (Appendix 3).

People of Javier Mina consider that mushrooms grow throughout the year and group the species into two categories: *hongos de cuaresma* 'Lenten mushrooms' or

hongos de secas 'mushrooms of the dry season', in which some *Ramaria* and *Lyophyllum* species are included and *hongos de temporal* 'mushrooms of the rainy season', in which most species, both edible and poisonous, are included.

Ecology.—The knowledge that people have about mushroom ecology varies from one community to the other. It depends on the activities in which they engage and on their dependence on forest resources.

People from Ixtenco recognize three ecological zones in which mushrooms grow. "El campo" refers principally to agricultural fields and open areas. They often refer also to "el cerro" (the hill) and "el monte" (the mountain, the place where the forest is). In Javier Mina, people also recognize three zones in which mushrooms can be collected: "el campo" (the cultivated fields), "el llano" (the plain), and "el monte" (the forests). In Los Pilares, just two of these zones are considered: "el campo" and "el monte". All the people have the same chance to go to the plain and to the forest, and they can collect plants, mushrooms or wood everywhere, because these are communal lands. Each family owns cultivated fields. The information obtained on this topic is showed in Appendix 4. People of the three towns consider La Malinche (the forest; Spanish: "el monte") to be the principal area for collecting mushrooms.

People from Javier Mina and Los Pilares have an extensive knowledge about the places in which diverse mushroom species grow, especially those species which are sold or used regularly, e.g., *Amanita caesarea, Lyophyllum* spp., *Russula delica, Ramaria* spp., and *Gomphus floccosus.* Otomi people from Ixtenco gave precise data about few edible species. Some respondents from Los Pilares can easily find certain bodies of hypogeous mushrooms such as species of *Rhizopogon* (*papas* 'potatoes') and they know that some animals such as birds eat these mushrooms. Only a few people eat these species raw, confirming their edibility.

People from Javier Mina call groups of mushrooms of the same species *compañeros* 'mates' or *cuatitos* 'little friends'. They say that each mushroom has its mate because everywhere that one of them grows, there is always another nearby; they say, "son hermanos" (they are brothers). When people find a lone fruit body of *Boletus pinophilus* or *Amanita caesarea,* they look around and usually find more.

Gathering and Use.—The main means for obtaining mushrooms in Javier Mina and Los Pilares is through direct collection, but in Ixtenco, people buy them. The two former towns are located very near to the forest, but the latter is more than 8 km from the places in which most species grow.

Most of the people from this area use mushrooms as food. Many people, mainly from Javier Mina and Los Pilares, have developed a commercial activity by selling mushrooms, either in neighboring places or in big cities such as Puebla or Mexico City.

Mushrooms are rarely used for non-food purposes. Nevertheless, we found eight usage categories for mushrooms in the area of study (Table 3). Only a few people recognized most of these categories. Mushrooms represent an important element of the economy of many families from Javier Mina and Los Pilares; however, fewer mushroom uses are recognized in these communities than in Ixtenco. The uses of mushrooms as fuel, decoration, or as an aid in beauty treatments in

TABLE 3.—Usage categories found in the studied area.

	Ixtenco	Javier Mina	Los Pilares
Food	*	*	*
Tinder	*	–	*
Cosmetic	*	–	–
Insecticide	*	–	*
Medicine	*	*	*
Ornament	*	–	–
Item for sale	*	*	*
Poison	*	*	*

(*) Data obtained in this town. (–) No information recorded in the present survey.

this country have not been previously documented, but these were recorded only in Ixtenco. Only a 23-year old woman indicated the cosmetic use.

Food.—A total of 121 common names used to designate 40 species of mushrooms and slime molds were found; these represent 16% of the total number of edible species registered in Mexico (Villarreal and Pérez-Moreno 1989). The use given to each species is variable and depends upon each person's individual knowledge and preference.

Mushrooms considered to be of excellent quality by most people are the following species: *Amanita caesarea, Boletus pinophilus, Lyophyllum ovisporum, Entoloma clypeatum, Hebeloma* aff. *mesophaeum,* and *Ramaria* spp.

The following species were known to over 95% of the inhabitants of the three communities; *Amanita caesarea, Boletus pinophilus,* and *Lyophyllum ovisporum.* In Javier Mina, they are greatly appreciated in an immature state (*de botón* 'bud'), commanding a higher price than those in a more mature state (*floreados* 'flowered'). These mushrooms are increasingly searched for, and are collected excessively, either for sale or for consumption. On many occasions, however, unsold dried mushrooms may remain stored for many years.

Mushrooms that were greatly appreciated and recognized by at least 40–80% of the interviewed people include the following species: *Cantharellus cibarius, Russula delica, Hygrophorus chrysodon, Gomphus floccosus, Agaricus campestris, Lactarius salmonicolor, Lactarius deliciosus, Laccaria bicolor,* and *Helvella lacunosa.*

Many of these species are occasionally collected in an immature state; even though some are avidly searched for, few people recognize them and the carpophores remain uncollected, thus allowing the species to reproduce.

Amanita franchetii and *Amanita rubescens* are used only in Javier Mina and few people recognize them. The presence of scales on the surface of the cap of these species is the reason many people consider them to be poisonous. They remain under-used, notwithstanding the high demand and the great appreciation that exists among people who know them.

The species named by less than 40% of interviewees include the following species: *Hygrophorus purpurascens, Clitocybe gibba, Gymnopus dryophilus, Chroogomphus jamaicensis, Clavariadelphus truncatus, Rhizopogon* aff. *michoacanicus, Climacocys-*

tis borealis, Ganoderma sp., *Lactarius indigo, Suillus granulatus, Boletus luridiformis, Fuligo septica, Tricholoma flavovirens,* and *Helvella crispa.*

Some species, such as *Lactarius indigo* and *Boletus luridiformis,* are considered toxic; in the first case, because of its blue-green color, and in the second, because of the greenish color that it acquires when the carpophore is damaged or cut. The last criterion is the same used as that used by people from Acambay in the State of Mexico (Estrada-Torres 1987) and by the Zapotecs from Oaxaca (Hunn, letter 2001)[1], who distinguish the edible *Boletus* sp. from poisonous species by testing the color of the flesh of the cap. If it turns green when broken, the mushroom is poisonous; if it remains creamy white, it is edible.

Characteristics such as mushroom consistency and shape make some species disagreeable, so people do not consume them. Such is the case with *Rhizopogon* aff. *michoacanicus* which, probably due to its dark and gelatinous gleba, is consumed by only a few people in Los Pilares. In a similar manner species of this genus are greatly appreciated by the Tepehuanes of Durango (González-Elizondo 1991). *Fomitopsis pinicola* and *Ganoderma* sp. are not used extensively because of their rubbery texture, and *Fuligo septica* due to its soft and gelatinous appearance.

Some genera, such as *Morchella,* are hard to find because they grow in areas that are difficult to reach and have a restricted distribution, even though they are greatly appreciated because of their flavor, as well as for their commercial value. Other mushrooms are not used simply because their flavor is disagreeable or because people either do not like them or do not know how to prepare them.

Mushroom preparation. The recipes used to prepare mushrooms for consumption are diverse and vary according to the custom of each family, their economic situation, and the type of mushroom. Although mushrooms are usually collected for sale, some are picked for consumption at home. In Ixtenco, mushrooms are bought.

The basic ingredients necessary to prepare mushrooms are garlic, onion and salt, depending upon how they are cooked; however, other herbs can be used, such as mint, epazote and pipitza (*Porophyllum tagetoides* (HBK) DC.), laurel, or cinnamon.

In the case of the *pante* (*Boletus pinophilus*), the *amarillo* ('yellow'; *Amanita caesarea*), and the *pancita (Suillus granulatus*), the carpophores are cleaned by peeling off the cuticle and cutting off the lower portion of the stem. The *corneta de oyamel* ('fir horn'; *Gomphus floccosus*) are cleaned of their veins and scales because, according to the people, these structures "are rust" due to their bitter taste; in the case of the *corneta blanca* ('white horn'; *Russula delica*), the gills are removed for the same reason. Depending on the flavor, mushrooms may or may not be washed; some people consider that washing eliminates their flavor or makes them slimy as in the case of the *pante.*

The blue mushroom (*Lactarius indigo*), the *pante,* the *paltecosa* (*Chroogomphus jamaicensis*), the *tecosita* (*Cantharellus cibarius*), and the *hongo del maguey* 'mushroom of the maguey' (*Pleurotus opuntiae*) can be eaten roasted or baked. It is recommended that the *pante* be prepared fried in lard with salt, which is said to taste like *chicharrón* (crackling) when prepared in this manner.

The yellow mushroom (*Amanita caesarea*), the *mantecado* (*Amanita rubescens*), the *xolete* (*Lyophyllum decastes*), and the *hongo de pasto* ('grass mushroom'; *Agaricus*

campestris), can be fried with slices of chili. The *pante* (prepared as a croquette) and the *escobetas* (*Ramaria* spp.) are recommended mixed with eggs.

Another way to cook them is in soup, with chicken, or just with epazote and onions or with slices of *cuaresmeño* chili. Mushrooms that are prepared in this way are the *escobetas,* the *xoletes,* the *amarillo,* the *hongo de pasto,* the *huevito* (*Hygrophorus chrysodon*), and the *tejamanil* (*Clitocybe gibba*). Some stews are more sophisticated; they are prepared in *pipián,* with green mole with peas or kidney beans. The *menudito* (*Morchella* spp.) is prepared stuffed with mashed potatoes, cheese, or ground meat, covered with beaten egg and fried. The *hongo de maguey,* the *enchilado* (*Lactarius salmonicolor*), and the *corneta blanca* are ground in the metate with epazote and chili to prepare quesadillas. It is recommended that the *hongo de pasto,* the *tecosita,* and the *xocoyulado* (*Laccaria bicolor*) be boiled with beans.

Mushroom preservation. One way to preserve mushrooms in order to enjoy them "para el antojo" (for cravings) in any season is to dry them in the sun, either sliced (as is the custom in Javier Mina), or strung on a thread (as mentioned by people in Ixtenco and Los Pilares). People from Javier Mina dry great quantities of mushrooms on screens; they take their mushrooms to Mexico City in order to sell them. Their price is greatly increased in this way.

Mushrooms that are customarily dried are the *pante,* the *menudo* or *morilla,* the *tecosita,* and the *orejas* (*Helvella* spp.). Species dried less frequently are the *corneta blanca,* the *corneta de oyamel,* the *escobetas,* and the *xolete.*

Beauty Treatments.— Ustilago maydis is used in some beauty treatments for refreshing the skin and giving softness. People mix the spores of this fungus with lemon juice and smear the mixture on the face as a mask.

Decoration.—Some people from Ixtenco use *Fomitopsis pinicola* (Sow.) Kickx and *Ganoderma* sp. to decorate Nativity scenes at Christmas time. People perforate the centers of the sporophores and use them to represent fountains, rocks or any other element in the display ("crèches"). Some people sell the sporophores of these species in the Huamantla market. We found these species in the market only at Christmas time.

Tinder.—Woodcutters and other people who have to stay in the forest for many hours or overnight use dried and old sporophores of *Fomitopsis pinicola* and other big polypore species to light fires to prepare meals or to provide warmth.

Medicine.— Ustilago maydis (*cuitlacoche*) is used to dress and promote the healing of burns in the three communities. Spores of this species are mixed with cold cream or lard. The mixture is smeared on the burned areas of skin.

Lycoperdon perlatum Pers. and other species of *Lycoperdon* (*pedo de coyote* 'coyote's flatulence') are used to heal wounds, burns and blotches. For wounds, the damaged skin is disinfected with alcohol, and the spores are then put on the wound. For burns, the fresh or dried sporophores are used in a similar way to that of *Ustilago maydis.* For skin blotches, it is necessary to clean the affected zone first. Spores are put on two or three times until the blotches dry. People from Javier Mina and Ixtenco mention medicinal uses of *Lycoperdon* spp.

Amanita muscaria (L.) Pers. (*yema venenosa* 'poisonous yolk' or ***khowiwe*** =

hongo mosca) is used to heal dysentery in Javier Mina. The mushroom is boiled and the water is drunk as an infusion.

Pseudevernia consocians (Vain.) Hale & Culb. and *Ramalina* sp., are used as a cure for pneumonia. These lichens are pulverized and mixed with alcohol, then the mixture is smeared on the chest. Many species of lichens (*flor de piedra* 'stone flower' or *lama de piedra,* 'stone slime') are used to make a tea to heal coughs.

Insecticide.—*Amanita muscaria* is used to kill flies. The cap and warts are put into a dish with milk or water mixed with sugar, and set aside indoors.

Poison.—Those mushrooms that people do not use for eating are considered to be poisonous. In Ixtenco, people call them ***khominikho*** (*hongos que no sirven* 'useless mushrooms') or ***tsangokho*** (***tsango*** 'poison' or 'rabies'; ***kho*** 'mushroom'; Spanish: *veneno* or *rabia* 'mushroom of rabies'). The general names in Spanish for these are *hongos locos* 'crazy fungi' and *hongos malos* 'crazy fungi' in all three localities.

Commercialization.—During the rainy season, mushroom selling is a very important activity, especially in Javier Mina, where 73% of people dedicate themselves to this operation. In Javier Mina, 102 families were interviewed. Seventy-five of them (59 women and 16 men) collect and sell mushrooms every day during the rainy season. A family spends 7 to 10 hrs collecting wild mushrooms, and walks about 8 to 20 km round trip. On average, each family collects 5.3 kg obtaining US $4.25 (29.09 Mexican pesos) per day (1 dollar = 6.85 pesos in 1995). Storeowners in the communities hoard mushrooms throughout the whole season in order to sell them later at a higher price in Puebla and Mexico City, to both local and to foreign buyers (mainly from Argentina). On average storeowners buy 82.23 kg of wild mushrooms per day and pay US $54.80 (375.35 Mexican pesos), which they resell in Mexico City or Puebla City. The inhabitants of Javier Mina are considered *hongueros* 'mushroom collectors' by the people of the surrounding communities. In Los Pilares, 3% of the interviewed people collect mushrooms to sell in their own community, as well as in the market of Huamantla.

Both large- and small-scale marketing exists. In the first case (only in Javier Mina), the sale is carried out by individuals who own pickup trucks. They take mushroom collectors to distant woods in order to find a greater quantity of mushrooms; the one condition is that the harvest be sold to those providing the transport. In this way, both sides benefit: the collector finds more mushrooms and obtains more money and the buyer also obtains a greater harvest of mushrooms for retail. Hoarders sell both fresh and dehydrated mushrooms; dry mushrooms are more expensive, but the crop must be young and well dried in order to be accepted.

Large-scale mushroom sale is an activity that has both advantages and disadvantages for the inhabitants of the community. The mushroom trade provides some work for children who, besides being collectors, are employed and paid to clean and slice mushrooms. On the other hand, the effect that excessive collecting and over-exploitation has on some species is unknown. In addition, the price paid per kilogram to the collectors is very low in relation to the work and effort involved.

Mushroom price varies according to abundance; when there are many, the

TABLE 4.—Mushroom prices in Javier Mina.

Latin name	Price in 1990 (US $1 = 2.85 Mexican pesos)	Price in 1995 (US $1 = 6.35 Mexican pesos)	Price in 2000 (US $1 = 9.70 Mexican pesos)
Amanita caesarea	$ 1.05–2.80/kg	Immature carpophores $ 1.73–2.36/kg Mature carpophores $ 0.63–0.94/kg	Immature carpophores $ 2.07/kg Mature carpophores $ 0.97/kg
Boletus pinophilus	$ 1.75–3.50/kg	Immature carpophores $ 0.78–1.10/kg Mature carpophores $ 0.31–0.47/kg	Immature carpophores $ 2.07/kg Mature carpophores $ 0.61/kg
Hebeloma aff. mesophaeum	$ 0.17–0.87/kg	$ 0.15–0.55/kg	$ 0.62/kg
Lyophyllum decastes	$ 1.75–3.50/kg	$ 0.94–1.25/kg	$ 2.07/kg
Lyophyllum ovisporum	$ 1.75–3.50/kg	$ 0.78–1.25/kg	$ 2.07/kg
Morchella esculenta	$ 2.45–5.26/kg	$ 0.16–0.31/kg	$10.39/kg

price diminishes. Table 4 shows the prices per kilogram of some of the main species that are collected in the community of Javier Mina.

Small scale mushroom trading is carried out within the communities, in neighboring communities, and at the marketplace in Huamantla. Here, the only beneficiaries are the mushroom collectors, for there is no middle-man. This is a very important activity; it is carried out by most of the collectors in Los Pilares and in Javier Mina and represents a considerable source of income during the rainy season. When the mushroom season is poor, people dedicate themselves to other related activities such as the collection and sale of Mexican cherries (*capulín;* seed fruits of *Prunus serotina* spp. *capuli* (Cav.) McVaugh.).

According to the information provided, in Ixtenco, the collection of mushrooms for sale in the neighboring communities was once a common activity. Nowadays, however, this activity is sporadic.

GENERAL DISCUSSION

This study provides a brief summary of traditional mycological knowledge from three towns within the same ecological area. Data presented are very similar to those found previously in other places and cultures in Mexico.

Regarding the conceptions about fungi, a high percentage of people from Ixtenco answered that mushrooms are plants, while in Javier Mina and Los Pilares over half of the population interviewed hold this view. Many people answered that these organisms are only "mushrooms," different from plants, like the conception that Purepechas from Michoacán have (Mapes et al. 1981). The oldest people in Ixtenco also view mushrooms as distinct. They use a special classifier for designating mushrooms, ***kho***, which is the same as that used by the Otomies from Acambay, State of Mexico (Estrada-Torres and Aroche 1987).

As in other areas of Mexico, people use specific terms to name the mushrooms structures. Otomies from Ixtenco name the cap (***rüphwi***), scales (***dañ̃i***), and stipe (***rwa***) in the same way that Otomies from the State of Mexico (Estrada-Torres and

Aroche 1987); nevertheless, we did not find any name for volva (Otomies call this structure ***rdéshkho*** in the State of Mexico). People from Javier Mina name all mushroom structures, and the volva and annulus are considered propagules. They believe that leaving these structures behind in the forest will increase the harvest in future years.

Some traditional practices in Javier Mina should be adopted by other collectors in the studied area because such practices could help to preserve this important resource. This is the result of the belief and understanding about the origin of mushrooms. People leave or bury some portions of the collected carpophores (volvas or stipe bases), and these structures may act as vegetative propagules. As far as we know, no scientific study has been done to evaluate the effectiveness of these practices. Other cultural practices include burning the herb layers of the forest with the aim of propagating some grasses used as fodder and at the same time promoting the production of some fungal species such as *Hebeloma* aff. *mesophaeum, Lyophyllum* spp., and *Morchella* spp., which grow in burned places. Such activities indicate some kind of forest management in which one objective is to increase the natural production of different edible species of wild mushrooms. Unfortunately, there is no research relating to the real impact of these practices on the natural production of mushrooms, on species selection, or of its effect on the forest itself. People of the towns are quite conscious of the dangers of uncontrolled fire. However, fires are started anonymously by persons who seemingly control neither the intensity nor the extent of the fire.

On the other hand, local ecological knowledge includes some concepts, such as that of "brothers" or "mates," that may help to convey ectomycorrhizal relationships in educational programs (to encourage sustainable use of forest). That is, mushrooms that are *hermanos* 'brothers' may have a common "mother" in the pine, fir or oak trees. The information that people have acquired could be used to indicate that a relationship exists between trees and mushrooms and something that damages one of them surely affects the other. If the people know that when they cut the pine trees, that is, the "mother" or host of young mushrooms such as *Boletus pinophilus*, then mushrooms will die and in later years they will find fewer of them to harvest. It will be important to make young people aware of the need to care for their forest resources, showing them relationships between different organisms using simple ideas. The information about traditional propagation of mushrooms would also be included in these kinds of programs. It is important to teach that mushrooms have spores, which are the seeds in that, if they leave spore-bearing pieces of the fruiting body, another mushroom may originate the next year in the same place. For this reason, it is important to clean the mushrooms in the forest and to bury unused portions of the sporophore.

Similar data related to mushroom uses have been reported in other parts of Mexico. For example, the Otomies of the State of Mexico (Estrada-Torres and Aroche 1987) use *Amanita muscaria* as an insecticide, as they do in Ixtenco, and Tepehuans from the State of Durango eat some species of *Rhizopogon*, as do people from Los Pilares. Commercialization of edible mushrooms in Javier Mina and Los Pilares is an important activity as is true in San Juan Atzingo, State of Mexico (Palomino-Naranjo 1992). It is important to point out that the use of mushrooms as food and as a market commodity provides an important complement to the

diet and income for many households of these towns, especially in the rainy season.

Traditional knowledge and experience of mushroom collectors, besides our studies of mushroom commercialization in this area, could form the basis for the promotion of rural enterprise, including the packaging of dry mushrooms or canning of some species, such as has been proposed by Martínez-Carrera et al. (1998).

As in Hueyapan, Morelos (De Avila et al. 1980), the northern mountains from the State of Puebla (Martínez-Alfaro et al. 1983), the Sierra of Ajusco (Gispert et al. 1984), and San Pedro de los Metates, State of Mexico (Estrada-Torres and Arroche 1987), people from the study area consider mushrooms to be "cold" in the traditional system of medicinal classification, due mainly to their high water content. However, as in Acambay, State of Mexico, some people from Javier Mina consider *Ustilago maydis* to be hot.

Mycological knowledge of the people of Javier Mina is probably very ancient and has survived to the present time through direct transmission from old to young people. This pattern is true also for Los Pilares.

In Ixtenco, old people provided similar information to that given by the young. Although our study did not aim to compare the ethnomycological knowledge between old and young people, it could be important to investigate this topic and to analyze some changes with time. It is possible that ethnomycological knowledge has been affected by local deforestation.

NOTES

[1] Hunn, Eugene. University of Washington, letter, November, 2001.

ACKNOWLEDGMENTS

We wish to acknowledge people from the study communities who shared their knowledge about edible mushrooms with us. We would like to thank Dr. David W. Mitchell, Dr. Rodham E. Tulloss, Marcia and Lawrence Leonard, and Naomi F. Miller for critically reading the English versions of this paper. We thank Dr. Roberto Escalante for the translation of Otomi names and Alejandro Kong for advising on the identification of mushroom specimens. Also we thank Alejandro de Ávila and Dr. Eugene Hunn for their improvements and suggestions to this manuscript.

REFERENCES CITED

Acosta-Pérez, Roberto and A. Kong. 1991. Guía de las excursiones botánicas y micológicas al Cerro El Peñón y Cañada Grande del estado de Tlaxcala. IV Congreso Nacional de Micología. Universidad Autónoma de Tlaxcala, Sociedad Mexicana de Micología, Jardín Botánico Tizatlán, Gobierno del Estado de Tlaxcala, Tlaxcala. *Folleto de divulgación* No. 8.

Chacón, Santiago. 1988. Conocimiento etnomicológico de los hongos del Plan del Palmar, Municipio de Papantla, Veracruz, México. *Micología neotropical aplicada* 1:45–54.

Coordinación General de Ecología. 1995. Programa de manejo del Parque Nacional La Malinche. Tlaxcala.

De Ávila, Alejandro, A. L. Welden and G. Guzmán. 1980. Notes on the ethnomycology of Hueyapan, Morelos, Mexico. *Journal of Ethnopharmacology* 2:311–321.

Dubovoy, Celia. 1968. Conocimiento de los hongos en el Mexico antiguo. *Boletín informativo de la Sociedad Mexicana de Micología* 2:16–24.

Escalante, Roberto. 1982. Clasificación matlalzinca de plantas y hongos. *Memorias del Primer Simposio de Etnobotánica.* I.N.A.H., México D.F.

Escalante, Roberto and Antonio López-González. 1971. *Hongos sagrados de los Matlalzincas.* Sección Lingüística 4, I.N.A.H., S.E.P., México, D.F.

Estrada-Torres, A. and Regla María Aroche. 1987. Acervo etnomicológico en tres localidades del Municipio de Acambay, Estado de México. *Revista mexicana de micología* 3:109–132.

Estrada-Torres, A., A. Kong, A. Montoya, and G. Santiago-Martínez. 1991. Listado preliminar de la micobiota del estado de Tlaxcala. In *Listado preliminar de la flora fanerogámica y micológica del estado de Tlaxcala. Talleres gráficos del estado de Tlaxcala.* Universidad Autónoma de Tlaxcala, Jardín Botánico Tizatlán. *Folleto de divulgación* No. 12.

Foster, George M. 1979. El legado Hipocrático latinoamericano: "caliente y frío" en la medicina popular. *Medicina tradicional* 2(6): 5–24.

García, Enrriqueta. 1988. *Modificaciones al sistema de clasificación climática de Köppen.* 4a. ed., ed. E. García. México, D.F.

Gibson, Charles. 1991. *Tlaxcala en el siglo XVI.* Fondo de Cultura Económica. México.

Gispert, Monserrat, O. Nava, and J. Cifuentes. 1984. Estudio comparativo del saber popular de los hongos en dos comunidades de la Sierra del Ajusco. *Boletín de la Sociedad Mexicana de Micología* 19:253–264.

González-Elizondo, Martha. 1991. Ethnobotany of the southern Tepehuan of Durango, México. Edible mushrooms. *Journal of Ethnobiology* 1 (2):165–173.

González-Fuentes, Ignacia. 1987. *Los hongos del estado de Tlaxcala.* Tesis profesional. ENEP, Iztacala, UNAM, Tlalnepantla.

Guzmán, Gastón. 1960. Nueva localidad de importancia etnomicológica de los hongos neotrópicos Mexicanos (Necaxa, Puebla). *Ciencia* (Mex.) 20:85–88.

Herrera, Teófilo and G. Guzmán. 1961. Taxonomía y ecología de los principales hongos comestibles de diversos lugares de México. *Anales del Instituto de Biología* 32:33–135. Universidad Nacional Autónoma de México.

INEGI. 1986. *Síntesis geográfica de Tlaxcala.* Instituto Nacional de Estadística Geografía e Informática, México, D.F.

———. 1991. *Tlaxcala. Resultados definitivos XI censo general de población y vivienda.* Tomo 1. Instituto Nacional de Estadística Geografía e Informática, México, D.F.

Mapes, Cristina, G. Guzmán, and J. Caballero. 1981. Etnomicología Purépecha. El conocimiento y uso de los hongos en la Cuenca del Lago de Pátzcuaro, Michoacán. *Serie etnociencia* 2. Dirección General de Culturas Populares (S.E.P.) y Sociedad Mexicana de Micología A.C., México, D.F.

Margulis, L. 1974. Five-kingdom classification and origin and evolution of cells. *Evolutionary Biology* 7:45–78.

Martínez-Alfaro, Miguel A., E. Pérez-Silva, and E. Aguirre-Acosta. 1983. Etnomicología y exploraciones micológicas en la Sierra Norte de Puebla. *Boletín de la Sociedad Mexicana de Micología* 18:51–64.

Martínez-Carrera, Daniel, M. Soval, A. Aguilar, M. Navarro, M. Bonilla, and A. Larque-Saavedra. 1998. Canning technology as an alternative for management and conservation of wild edible mushrooms in Mexico. *Micología neotropical aplicada* 11: 35–51.

Moser, Meinhard. 1983. *Keys to Agarics and Boleti (Polyporales, Boletales, Agaricales, Russulales).* Roger Phillips, London.

Muñoz-Camargo, Diego. 1586 (1984). Descripción de la ciudad y provincia de Tlaxcala. Edición facsimil de la obra inédita de 1586. In *Relaciones geográficas del siglo XVI Tlaxcala,* ed. René Acuña. UNAM, México, D.F.

Palomino-Naranjo, Armando. 1992. *Etnomicología tlahuica de San Juan Atzingo.* Tesis de Licenciatura, ENEPI, UNAM, Tlalnepantla, Estado de México.

Reygadas-Prado, Fabiola, M. Zamora-Martínez, and J. Cifuentes. 1995. Conocimiento sobre los hongos silvestres comestibles en las comunidades de Ajusco y Topilejo, D.F. *Revista mexicana de micología* 11: 85–108.

Santiago-Martínez, Guadalupe, A. Kong, A. Montoya, and A. Estrada-Torres. 1990. Micobiota del estado de Tlaxcala. *Revista mexicana de micología* 6: 227–243.

Toledo Víctor, M., J. Carabias, C. Mapes, and C. Toledo. 1985. *Ecología y autosuficiencia alimentaria.* Siglo XXI, México, D.F.

Villarreal, Luís and J. Pérez-Moreno. 1989. Los hongos comestibles silvestres de México, un enfoque integral. *Micología neotropical aplicada* 2:77–114.

Weitlaner, Roberto. 1933. El dialecto Otomí de Ixtenco, Tlaxcala. *Anales del Museo Nacional de Arqueología, Historia y Etnografía.* (4ª Época) 8(4):279–285.

APPENDIX 1.—Questions used to obtain information about traditional mycological knowledge.

1. Name
2. Age
3. Occupation
4. Address
5. Are you familiar with fungi?
6. Can you explain fungi?
7. Name the fungi that you know
8. What are the uses of fungi?
9. Where do the fungi grow?
10. When do fungi grow?
11. How do they originate?
12. What conditions do they need to come?
13. What is the quality of fungi? Are fungi cold, hot or warm?
14. Why is this so?
15. Do all fungi grow in the same place?
16. What are the names of the fungi structures? (with picture shown as reference)
17. Which fungi are edible?
18. How do you cook mushrooms?
19. How do you know an edible fungi?
20. Which fungi are inedible?
21. What happens if you eat inedible fungi?
22. Are inedible fungi useful for something?
23. What remedies are used for people who eat inedible fungi?
24. Do you know fungi which are used as a remedy?
25. Do you collect fungi?
26. Do you buy fungi?
27. Do you sell fungi?
28. Which fungi do you sell?
29. Where do you sell fungi?
30. Do you know how to preserve fungi?
31. Do you know how to sow fungi?
32. Are you familiar with cuitlacoche?
33. Are they fungi?
34. What are they?
35. What is its use?

APPENDIX 2.—Species and common names used by people in the visited communities.

Latin name & voucher specimens	Spanish name	Otomi name	Nahua name
Agaricus campestris L. Montoya 1644	champiñón (1,2,3), llanero (1,2,3), hongo de pasto (1,2,3)		
Agaricus sp. Montoya 491, 970	soles (2)		
Amanita caesarea (Scop.) Pers. Montoya 13, 269, 618; Kong 616	ahuevadito (1,2), hongo amarillo (1,2,3), hongo flor (1,2,3), jícara buena (1,3)	***kaxkho*** kax = amarillo kho = hongo	***xochinanácatl*** xochitl = flor nanácatl = hongo
Amanita franchetii (Boud.) Fayod Montoya 754, 613, 530, 644; Kong 1310	yema (2,3)		
Amanita rubescens (Pers.) Gray. Montoya 127, 589	amantecado (2), chintete (1), mantecado (2)		
Boletus pinophilus Pilát. & Dermek. Montoya 09.05.1990, 291, 519; Estrada-Torres 2941; Kong 677	esponja (1), el pan (1) ongorao (2), pambazo (2), pante angora (2), pante (2,3), pante blanco (2), pante morenito (2), pante de zacatón (2), seta (2)	***khopante*** kho = hongo ***khodme*** dme = poros	***xotoma***
Boletus atkinsonii Peck. Montoya 1672	pante cimarrón (2)		
Calvatia cyathiformis (Bosc) Morgan Montoya 823	cempamil (1,2,3)		
Cantharellus cibarius Fr. Montoya 392, 539, 738; Hernández-Valencia 32	duraznillo (2,3), flor de duranzo (1), tecosa, tecosita (1,2,3)		
Chroogomphus jamaicensis (Murril) O.K. Mill. Montoya 386, 526	clavillo (1), tlapaltecosa (2), tecosa moradita (2,3), tlaltecosa (2,3), paltecosa (2,3)	***grawxi*** = clavillo	
Clavariadelphus truncatus Donk Kong 2144; Montoya 524, 807	flauta (2)		

APPENDIX 2.—(continued)

Latin name & voucher specimens	Spanish name	Otomi name	Nahua name
Climacocystis borealis (Fr.) Kotl. & Pouzar Kong 2099	hongo de palo (1)		
Clitocybe gibba (Pers.) P. Kumm. Montoya 822; Estrada-Torres 2562	güerita (1,2), popotitos (3), sombrerito (1,2,3), tejamanilero (1,3)		
Entoloma clypeatum (L.) P. Kumm. Montoya 843, 986	rosita (2)		xolete rosita* (2,3)
Fuligo septica (L.) F.H. Wigg. Montoya 313	hongo de palo (1,2,3) hongo de tronco (3)		
Gomphus floccosus (Schwein.) Singer Montoya 388, 703	corneta amarilla (1,2,3), corneta colorada (2), Corneta de oyamel (2,3), trompetilla (1,3)	***ixibaswa*** ixi = durazno corneta de oyamel ***wawikho*** wawi = oyamel kho = hongo corneta de oyamel	
Gymnopus dryophilus (Bull.) Murrill Montoya 590	señorita (1,2) paragüitas (1,2), popotitos (2)		
Hebeloma aff. *mesophaeum* Fr. Montoya 1643; Hernández-Díaz 15	hongo de ocote (1,2,3)	***kho Tädi*** kho = hongo tädi = ocote	***ocoshalero*** (2), hongo de ocoshal* (1) (2), xolete amarillito* (2), xolete de ocoshal* (2,3)
Helvella crispa (Scop.) Fr. Montoya 700, 727; Kong 980	gachupín blanco (2), o. de padre blana (2), oreja blanca (2)		
Helvella infula Schaeff. Kong 927	oreja de padre roja (2)		
Helvella lacunosa Afzel. Montoya 206, 252, 516, 554; Estrada-Torres 2339	gachupín negro (2), o. de padre negra (2), ovispo (1), torito (3)		

APPENDIX 2.—(continued)

Latin name & voucher specimens	Spanish name	Otomi name	Nahua name
Helvella spp.	cresta de gallo (2), gallitos (1), orejas (2,3) oreja de ratón (1,2,3), pata de gallo (1)		
Hygrophorus chrysodon (Batsch.) Fr. Montoya 527, 543	huevito (1,2), lupitas (2), mariquitas (2), palomita (2), rotito (2), niños (1,2,3)		
Hygrophorus purpurascens (Alb. & Schwein.) Fr. Montoya 544	camarón (2)		
Laccariabicolor (Maire) Orton Montoya 583, 418, 761, 1120	cuerudo blanco (2), moradilla (3), morenito (1)		***xocoyul*** (2), ***xocoyulado*** (1,2,3)
Lactarius indigo (Schwein.) Fr. Montoya 706, 739	azul (1,2,3), conreta azul (2), panza de lagartija (2)	***kexke kho*** kexke = azul kho = hongo	
Lactarius salmonicolor Heim *et* Leclair Montoya 1013, 1027; Kong 711, 751	encilado (1,2,3) trompa de cochino (1,2)		
Lycoperdon perlatum Pers. Montoya 462, 621, 634, 678	hongo de bola (1), bolita de algodón (1), bolita de conejo (1), bolita de borrego (1), pedo de coyote (1,2,3), pedo de monja (1)	***rpich min kho*** pich = pedo min = coyote pedo de coyote	
Lyophyllum decastes (Fr.) Sing. Montoya 336, 971, 1126	hongo blanco (2), Clavo (2)		***iztacnanácatl*** (2) ***iztac*** = blanco ***nanácatl*** = hongo ***xolete*** (2), (it must be very delicate, ***xolectle*** is one easily hurt; De Ávila et al., 1980) xolete blanco* (1)

APPENDIX 2.—(continued)

Latin name & voucher specimens	Spanish name	Otomi name	Nahua name
Lyophyllum ovisporum (Lange) Reid. Montoya 962	blanco de mata (2), hongo de temporal (2)		xolete de temporal* (2,3)
Lyophyllum sp. Montoya 968	coxcomo (2), cuatcomo (2), cuscomo (2), blanco de mata (2), cuaresmeño (1,2,3) pechuga de gallina (2,3), tecoxcomo (2,3), hongo de trueno (3)		
Morchella elata Fr. Hernández-Valencia 29; Hernández-Díaz 58	chipotle (1,2,3) chultepín, elotito, morilla (2), menudo (1,2,3) Olote (1), Viejito (3)	***honti'ñi*** = chile = chipotle	
Morchella esculenta (L.) Pers. Montoya 857	chipotle (1,2,3) chultepín, elotito, morilla (2), menudo (1,2,3) olote (1), viejito (3)	***honti'ñi*** = chile = chipotle	
Pleurotus opuntiae (Durieu & Lév.) Sacc. Montoya 974	hongo de maguey (1,2,3)	***kho wadá*** ***kho*** = hongo ***wadá*** = maguey	
Ramaria flavobrunescens (Atk.) Comer. Estrada-Torres 2499	escobeta amarilla (1,2) escobeta cremita (2)		
Ramariarubripermanens Marr. & Stunz. Montoya 608, 636; Estrada-Torres 2246, 2353	escobeta morada (2)		
Ramaria spp.	escobeta (1,2,3)	***ntsanikho*** ntsani = escobeta kho = hongo	
Rhizopogon aff. *michoacanicus* Trappe & Guzmán Montoya 397	papas (3), mollejas (2)		

APPENDIX 2.—(continued)

Latin name & voucher specimens	Spanish name	Otomi name	Nahua name
Russula delica Fr. Montoya 497, 535; Kong 2255, 2705	borreguitos (2), corneta blanca (2), tecajete (2), pata de cabra (1,3)		
Suillus brevipes (Pk.) Kuntze Montoya 609[a]	pancita de llano (3)		
Suillus granulatus (Pk.) Kuntze Montoya 326	chipo de toro (3), panza (1,2,3), pancita (1,2,3), pancita de zacatón (1,2,3), poposo (2)		
Tricholoma flavovirens (Pers.) S. Lundell Montoya 196, 210, 486; Estrada-Torres 2676; Kong 951	cailita (2,3)		
Ustilago maydis (D.C.) Cordá Montoya 973		***döntha-kho*** milpa-hongo = cuitlacoche	***cuitlacoche*** (1,2,3)

Key: 1—Ixtenco, 2—Javier Mina, 3—Los Pilares; *—mixed names (Nahua/Spanish)

APPENDIX 3.—Mushroom growth season (x—Ixtenco; *—Javier Mina; o—Los Pilares).

Species	Months											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Amanita caesarea						xxxx ********** oooooooooooooooo						
Amanita franchetii						ooooooooooooooo						
Agaricus campestris				xxxxxxxxx ooooooooooooooooooooooo								
Boletus pinophilus						xxxx ********** oooooooooooooooo						
Calvatia cyathiformis						ooooooooooo						
Cantharellus cibarius						**********						
						ooooooooooooooo						
Clitocybe gibba						ooooooooooooooooooo						
Chrogomphus jamaicensis						ooooooooooo						
Entoloma clypeatum						**********						

APPENDIX 3.—(continued)

Species	Months											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fuligo septica						**********						
Gomphus floccosus						XXXX **********						
Hebeloma aff. *mesophaeum*						**********						
Helvella crispa						**********						
Helvella lacunosa						**********						
Hygrophorus chrysodon						**********						
						oooo						
Laccaria bicolor						*********						
						oooooooooooo						
Lactarius salmonicolor						oooooooooooooooooooooooo						
Lycoperdon perlatum						ooooooooooooooo						

APPENDIX 3.—(continued)

Species	Months											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lyophyllum decastes					xxxx							
				****		**********						
		oooo										
				oooooooooooooooooooooooooo								
Lyophyllum ovisporum												
	**********											
		oooooooooooo										
Morchella esculenta												
						**********						
						oooooooooooooooooooo						
Pleurotus opuntiae					xxxxxxxxxxxxxxxxxx							
					oooo							
Ramaria spp.	**********					**********						
						oooooooooooooo						
Rhizopogon aff. *michoacanicus*												
					oooo							
Russula delica						xxxx						
						**********						
						oooo			oooo			
Suillus granulatus and *S. brevipes*						**********						
						oooooooooooooooo						

APPENDIX 4.—Places where mushrooms grow.

	Ixtenco	Javier Mina	Los Pilares
Agricultural fields (Sp.: *el campo*)	Corn fields *Ustilago maydis* Parasitic on magueyes *Pleurotus opuntiae*	Corn fields *Ustilago maydis* Parasitic on magueyes *Pleurotus opuntiae*	Corn fields *Ustilago maydis* Parasitic on magueyes *Pleurotus opuntiae*
Grasslands (Sp.: *el llano*)	Grasslands *Agaricus campestris* *Calvatica yathiformis* *Lycoperdon perlatum*	Grasslands *Agaricus campestris* *Lycoperdon perlatum*	Grasslands *Agaricus campestris*
The mountain (Sp.: *el monte*)	Oak forest *Amanita caesarea* *Lactarius indigo* *Lyophyllum decastes* Pine forest (Sp.: *ocotal*): *Boletus pinophilus* (associated with grasses) *Laccaria bicolor* *Ramaria* spp. *Russula delica* *Hebeloma* aff. *mesophaeum* (burned areas) On fallen pine wood *Fomitopsis pinicola* *Ganoderma* sp.	Oak forest *Boletus atkinsonii* *Lactarius indigo* (in cattle ranch, Sp.: *potreros*) Pine forest (Sp.: *ocotal*): *Amanita caesarea* *Boletus pinophilus* (associated with grasses) *Hebeloma* aff. *mesophaeum* (burned areas) *Lycoperdon perlatum* *Lyophyllum decastes* (burned areas) *Morchella* spp. (burned areas) *Rhizopogon* aff. *michoacanicus* (underground) *Suillus brevipes* Pine-alder forest (Sp.: *ailites*) *Amanita muscaria* *Boletus pinophilus* Fir forest (Sp.: *oyameles*) *Gomphus floccosus* *Lactarius salmonicolor* *Helvella crispa* (on moss) *Helvella lacunosa* (on moss) *Morchella* spp. (on moss) In ravines *Lactarius salmonicolor* *Morchella* spp. *Russula delica* On fallen pine wood *Fuligo septica* *Fomitopsis pinicola*	Pine forest (Sp.: *en la ocotera*) *Amanita caesarea* (associated with grasses) *Boletus pinophilus* (associated with grasses) *Cantharellus cibarius* (among leaf trees) *Hygrophorus chrysodon* (among leaf trees) *Ramaria* spp. *Russula delica* (among leaf trees) Fir forest *Cantharellus cibarius* (among leaf trees) *Gomphus floccosus* (among leaf trees) *Helvella crispa* (on moss) *Helvella lacunosa* (on moss) *Morchella* spp. (on moss) On fallen pine wood *Climacocystis borealis* *Fuligo septica* *Fomitopsis pinicola*

Journal of Ethnobiology 22(1): 133–162 Summer 2002

'ORPHAN TREES OF THE FOREST': WHY DO NTUMU FARMERS OF SOUTHERN CAMEROON PROTECT TREES IN THEIR SWIDDEN FIELDS?

STÉPHANIE M. CARRIÈRE

IRD-Ile de France, 32, Avenue Henri Varagnat, 93 143 Bondy Cedex, France

ABSTRACT.—Many traditional tropical-forest swidden farmers protect trees during field clearing, but the motivations for this widespread practice have been little studied. I examined this question in a study of Ntumu swidden farmers in southern Cameroon. Remnant trees have a wide range of direct uses, but they also appear to be part of a conscious strategy of agroecosystem management at different scales of space and time. These 'orphan trees' are also integrated into the Ntumu thought system, as is shown by the richness of symbolism associated with them. To test the common presumption that trees are left in fields because farmers lack time, energy or tools to cut them, we studied the impact of introduction of the chain saw in this traditional system. In this stable society, introduction of this modern tool did not affect density of spared trees in fields. Finally, I discuss the long-term impact on the African rainforest landscape of selective sparing of certain tree species, and how the practice of sparing trees may be affected by socioeconomic change.

Key words: swidden horticulture, agroecosystem management, chain saw, social representation, remnant trees, fallow

RESUMO.—Em todas as florestas tropicais, certos cultivadores itinerantes deixam de cortar algumas árvores em seus campos de cultura. Mas esse hábito, embora muito corrente, tem sido pouco estudado até aqui, e os motivos que levam esses camponeses a poupar um certo número de árvores ainda não foram bem compreendidos. Analiso aqui esse costume praticado pelos Ntumus do sul da República dos Camarões. As ávores por eles poupadas prestam-se a vários usos na vida quotidiana e, acima de tudo, fazem parte integrante de estratégias para a gestão do sistema agrário, em diferentes escalas de espaço e de tempo. Além disso, essas "árvores órfãs" integram-se ao modo de pensar dos Ntumus, como o prova a riqueza simbólica que a elas está associada. A fim de pôr à prova a idéia preconcebida segundo a qual tais árvores são poupadas por falta de tempo ou de meios de produção (carburante, ferramentas, máquinas), fiz um estudo sobre o impacto causado pela introdução da moto-serra nesse sistema tradicional. Numa sociedade que ainda se acha preservada, a introdução dessa máquina moderna não perturba a densidade das árvores mantidas nos campos. Examino enfim o impacto, a longo prazo, do corte seletivo nas florestas da África central, e tento também avaliar em que medida essa prática tradicional poderia ressentir-se em razão das mudanças sociais e econômicas.

RÉSUMÉ.—Dans toutes les forêts tropicales certains cultivateurs itinérants épargnent des arbres au cours de l'abattage de leurs champs vivriers. Cette pratique très répandue demeure cependant très peu étudiée et les motivations des paysans

à laisser des arbres dans leurs champs sont encore peu comprises. Ici j'étudierai cette pratique chez les Ntumu du sud du Cameroun. Les arbres épargnés font l'objet de divers usages dans la vie quotidienne et surtout ils entrent dans la composition des stratégies de gestion de l'agrosystème et ce à différentes échelles d'espace et de temps. Ces "arbres orphelins" sont également intégrés au système de pensée des Ntumu comme en témoigne la richesse symbolique qui leur est associée. Pour tester l'idée préconçue qui prétend que ces arbres sont épargnés à cause du manque de temps ou de moyens (carburant, outils, machines), j'ai étudié l'impact de l'introduction de la tronçonneuse dans ce système traditionnel. Dans une société encore préservée, l'introduction de cette machine moderne n'affecte pas la densité des arbres laissés dans les champs. Enfin, je discute l'impact à long terme de l'abattage sélectif sur le paysage forestier d'Afrique Centrale et également dans quelle mesure cette pratique traditionnelle pourrait être affectée par le changement social et économique.

INTRODUCTION

The most widespread agricultural system in the tropics is slash-and-burn shifting cultivation or swidden cultivation (Conklin 1957; Bahuchet and De Maret 1993). This type of farming is often associated with a diversity of other subsistence activities, such as hunting, trapping, fishing, and gathering for food, medicines, and materials for tools and many other manufactured items. This kind of diversified subsistence system, termed "horticulture" (Johnson 1983), is typical of farmers in the African rainforest. Adapted to low population density for subsistence production (Boserup 1965), traditional swidden cultivation is today recognized as an ecologically sustainable system (Conklin 1957; Geertz 1963; Sanchez 1976; Kang et al. 1984; Beets 1990; Whitmore 1990). Swidden cultivators use the land by creating an equilibrium between forest dynamics and crop cultivation in order to sustain food production over the long term (Gliessman 1985). Using knowledge gained by long experience, farmers manage forest regeneration to restore soil fertility between cycles of cultivation. This practice is based on the understanding that cutting and burning of vegetation adds nutrients to the soil (Benneh 1972).

Traditional swidden farming systems include many practices to enhance crop production as well as forest regeneration. Sparing remnant trees in the fields is an ancient and common practice in Central and West Africa (Bahuchet and De Maret 1993; Dounias 1993; De Wachter 1997; Rösler 1997; Sirois et al. 1998; Carrière 1999) and in Southeast Asia (Conklin 1957; Dove 1985; Ellen 1996, 1998), but is not often found in some Amazonian swidden agricultural systems, for example in French Guyana (Grenand and Haxaire 1977; Grenand 1979). Farmers often consider remnant trees in fields valuable for social reasons. Spared trees often belong to species with special cultural significance (Conklin 1957; Fosbrooke 1974; Denevan et al. 1984; Dove 1985; De Rouw 1991; Dounias 1993; Ellen 1998; Sirois et al. 1998; Carrière 1999), but the reason why traditional farmers leave trees in such systems has been little studied. Moreover, remnant trees contribute to forest regeneration in the fallows (Carrière 1999; Carrière et al. 2002a) by providing favorable conditions (nutrients and moisture) for the establishment of forest species (Buschbacher et al. 1988; Nepstad et al. 1991; Belsky and Canham 1994; Viera

et al. 1994; Sirois et al. 1998) and by attracting seed dispersers, increasing the seed rain and thereby increasing the rate of regeneration under the crowns of such trees (Wegner and Merriam 1979; McDonnell and Stiles 1983; Guevara et al. 1986; McClanahan and Wolfe 1987; Janzen 1988; Guevara et al. 1992; McClanahan and Wolfe 1993; Viera et al. 1994; Cardoso Da Silva et al. 1996; Nepstad et al. 1996; Carrière 1999; Carrière et al. 2002b).

While the practice of protecting selected trees in cleared fields has often been observed in Central Africa and many other parts of the tropical world, very few studies attempt to explain it. Many authors have considered the practice to be the result of laziness or simply the lack of technical means (or of sufficient labor force) to deal with large trees, which often possess very hard wood (for studies criticizing this common notion see Dove 1985; De Rouw 1991; Dounias 1993; De Wachter 1997; Rösler 1997; Ellen 1998). However, plants may be preserved deliberately as well as by default, and many techniques are reported which involve varying degrees of protection of otherwise wild species (Dove 1985; Rambo 1985: 71; Ellen 1994:205–206; Carrière 1999). A considerable number of individual trees are spared during field clearing, and many species are represented. It is possible that, for as long as swidden cultivation has existed in Central African forests, some tree species have been spared and therefore favored in this area.

The indigenous classification of biological communities and folk systematics has received more attention than has indigenous ecological knowledge of forest dynamics. The goal of this study is to contribute to an understanding of how and why farmers leave some 'orphan trees'—as they are called by the Ntumu of southern Cameroon—in newly cleared fields. I examine to what extent this ancestral practice is the reflection of a real understanding of forest dynamics by native farmers, leading to greater adaptation of agricultural practices to a rainforest environment. Finally I will describe and interpret the social representations of remnant trees in fields in this group of traditional slash-and-burn horticulturists.

THE NTUMU REGION

The Ntumu speakers occupy the north bank of the Ntem river in southwestern Cameroon, and adjacent areas of northern Gabon and Equatorial Guinea (Figure 1). They belong to the Beti-Fang linguistic group (Guthrie 1948). The village of Nkongmeyos (2°27′N, 10°27′E), with about 245 inhabitants, is located on a plateau about 500 m asl, at the margin of the Ntem Valley (Anonymous 1990). The mean annual temperature is about 25°C and the site receives approximately 1497 mm of rainfall annually (data for Nyabessan (2°24′N, 10°24′E) 1976–1980) (Anonymous 1990). Seasonality is of the equatorial type, with two rainy seasons and two dry seasons (short rainy season from March to June, long dry season from June to August, long rainy season from September to December and short dry season from December to March). This alternation of the two rainy seasons is typical of equatorial regions. Although Nkongmeyos is north of the equator, the long dry season there occurs during the period usually characterized by a short dry season over most of southern Cameroon, and the short dry season occurs during the usual long dry season. This peculiarity is due to the orographical conditions of the region and the overall orientation of the Ntem Valley (Suchel

FIGURE 1.—Location in southern Cameroon of the Ntem valley and the Ntumu village in which the study was carried out.

1972). The surface geology is dominated by sedimentary and metamorphic rocks (Letouzey 1985). The hydrographic network is very dense, mainly composed of the four main branches of the Ntem, which run from east to west and are joined by many small tributaries, the flow of which varies considerably according to the seasons.

Three types of soils predominate: (1) yellow ferralitic soils originating from metamorphic rocks, (2) orthic ferralitic soils and (3) hydromorphic soils. All these soils are acid and poor in nutrients (Letouzey 1985). Predominant original vegetation is classified as transitional between semi-deciduous forest of areas to the north and the evergreen Congolean rain forest found to the south and east (Letouzey 1985), with many tree species typical of old secondary forests (no agricultural disturbance for over a century), such as *Ceiba pentandra* Gaertn. (Bombacaceae), *Terminalia superba* Engl. and Diels (Combretaceae), *Pycnanthus angolensis* (Welw.) Exell (Myristicaceae), *Triplochiton scleroxylon* K. Schum. (Sterculiaceae), *Lophira alata* Banks ex. Gaertn. (Ochnaceae), *Canarium schweinfurthii* Engl. (Burseraceae), many species of *Macaranga* (Euphorbiaceae), and *Petersianthus macrocarpus* (P. Beauv.) Liben (Lecythidaceae) (Letouzey 1985). Young secondary forests are dominated by a few abundant pioneer species such as *Musanga cecropioides* R. Br. (Moraceae), *Trema guineensis* Schum. and Thonn. (Ulmaceae), *Alchornea floribunda* Müll. Arg. (Euphorbiaceae), and many species of large herbaceous monocots (Zingiberaceae, Marantaceae and Commelinaceae) which compose the dense undergrowth of secondary forests. The whole area is surrounded by old secondary forest, and many patches of this kind of forest are found throughout the village's territory (Carrière 1999).

Apart from the practice of traditional agriculture, the area described is characterized by little human disturbance. There is no logging and no conservation-management or development projects. Population density is low, about 7 inhabitants/km^2 (Carrière 1999). However, small populations of hunter-gatherers and traditional swidden horticulturalists have lived in the area for about 2000 years. Beginning with German colonization in southern Cameroon, permanent villages have been established increasingly along the roads (Bahuchet and De Maret 1993), and consequently areas allocated to agriculture are also located on either side of the road. Ancient cultivation by humans in the Ntem Valley, as well as in many other parts of the Central African forests, has had a large influence on vegetation composition, by increasing the percentage of some secondary-forest species (Letouzey 1985).

FARMING SYSTEM

In southern Cameroon, each human population has its own characteristic field composition and crop sequence, and thus its own particular land-use cycle (Bahuchet and De Maret 1993). After field (***afup*** 'field') clearing, Ntumu cultivators use two kinds of rotation, which differ solely in the presence or absence of a first crop of *Cucumeropsis mannii* Naud. (Cucurbitaceae). In the first type of rotation, after preparing a field of about one hectare from primary or secondary forest (15 years old or more), *C. mannii* (***afup ngwan*** 'field of *C. mannii*') is planted. The vines of this crop, cultivated for its seeds that are used to prepare sauces and cakes, climb on dead burnt trunks in the fields for one season. After harvest of ***afup ngwan***, about 0.3 ha of the field is re-cleared and sown with peanuts (***afup owono*** 'field'; 'peanuts': *Arachis hypogea* L., Papilionaceae), just before the start of one of the two annual rainy seasons. Thus, three to four ***afup owono*** could be prepared from an ***afup ngwan***. In other words, one hectare of cleared land will

lead to the production of four seasons of peanuts. This is a good example of the capacity of swidden agriculture to maximize the profitability of labor input (Beets 1990). Moreover, maize, onions, tomatoes, sweet potatoes, plantain, cassava, and many other crops may all be planted among the peanuts. After the peanut harvest, staple crops such as cassava, yams, taro, plantain and sweet potatoes begin growing and can be harvested after six months. The amount of time spent weeding decreases dramatically after peanuts have harvested and secondary vegetation begins to take over. The old field is termed ***kumu***, meaning literally "old field", and its distinguishing characteristic is the temporary coexistence of secondary regrowth and cultivated plants. After a time, when farmers have to search to find food in the overgrown field, it becomes a young fallow field (***enfefeng ekolok*** 'young'; 'secondary regrowth'). Ntumu farmers do not wait for production to decrease before "abandoning" a field; rather they anticipate this decrease and move prior to it, because they know that the necessary period of fallow increases with the intensity of land use. The minimum length of a fallow period in this area is about 15 years.

The second type of crop succession is similar, but lacks the ***afup ngwan*** first crop; it is created in relatively young secondary vegetation (about 15 years). In some cases, the planned future of a cultivated field is not a regenerating fallow, but a cocoa plantation for which large trees provide shade. Cocoa is the main cash crop of the region. In fields destined to become cocoa agroforest some initial practices are different. For example, during clearing a larger number of trees are left standing as shade trees for the cocoa and to increase the density of useful trees in the cash-crop agroforestry system.

Division of labor between the sexes in such Beti societies (Laburthe-Tolra 1981) results in the divergence of interests between Ntumu men and women with regard to how fields are cleared. The final result—which trees are felled and which are spared—is thus a sort of compromise. The components of the crop succession differ in their relevance to men and women. Because men's crops and women's crops differ in their needs for shade, there is a gender conflict regarding how fields are cleared. It has arisen largely as a result of the recent introduction of peanuts into the forest region of central Africa. Men's crops, especially plantain, require a lot of shade; requirements of *C. mannii* for shade are less. Women's crops, especially peanuts, do best with little shade. The way in which trees are cut or spared during field clearing must satisfy both men and women (Carrière 1999). This plantain/peanuts compromise must take into account the agroecological requirements of many other crops as well. After initial clearing, which is done by men, women approve or disapprove of the selection strategy. In general, men adjust the cutting if their women are not satisfied, because if his wife's field is not productive, a man loses respect (Carrière 1999). Despite the shared activity of agricultural production between men and women the final recognition goes to the owners of the field, that is to say, the men.

PRELIMINARY DEFINITIONS

Before discussing selective cutting as a traditional practice, it is important to define concepts and explain terminology. We define a 'practice' as a customary

action, appropriate to individuals and groups. The term 'traditional' implies that these practices have been culturally transmitted over many generations, learned in diverse ways by each new generation. A traditional practice is thus a social phenomenon, and like techniques in general, may vary from one culture to another (Lemonnier 1992). 'Techniques' are here defined as "means and processes used to make tools required for the acquisition and consumption of resources" (Leroi-Gourhan 1945). According to Mauss (Mauss 1935 cited by Lemonnier 1992), in his paper on body techniques, a technique is defined as "an action which is effective and traditional [and in this, according Lemonnier, it is no different from a magical, religious, or symbolic action] felt by the [actor to be] mechanical, physical or physico-chemical . . . and . . . pursued with this aim in view." For Lemonnier (1992), any technique has five related components: matter, energy, objects, gesture and specific knowledge. I will devote most attention here to the last component, which is defined by Lemonnier as follows:

> "the specific knowledge may be expressed or not by the actors, and may be conscious or unconscious. This specific technological knowledge is made up of 'know-how', or manual skills. The specific knowledge is the end result of all the perceived possibilities and the choices, made on an individual or a societal level, which have shaped that technological action. I call those possibilities and choices social representations. Some examples of social representations which shape a technology or technological action are: the choice to use or not use certain available materials and the choice of how the action itself is to be performed . . ." (Lemonnier 1992:6)

Selective cutting of trees during field clearing is a 'traditional' Ntumu agricultural practice. By the definition of Leroi-Gourhan (1945), selective cutting does not in itself constitute a human agricultural technology, but only a part of a technological process involved in agriculture and food crop production. Remnant trees in fields are used in many different subsistence production activities. Because the fleshy fruits of some species (along with many other traits) attract animals, remnant trees enhance the value of fields and fallows as hunting sites and could contribute to "garden hunting" as seen in the American tropics (Linares 1976). Remnant trees of some species provide edible fruits, poisons used in fishing, and other gathered products. Remnant trees may also have an important agroecological function, such as providing moisture, enhancing soil fertility or accelerating forest regeneration (Carrière 1999; Carrière et al. 2002a). If we accept Mauss's (Mauss 1935; Lemonnier 1992) definition, leaving remnant trees in fields can be described as a technique because trees are spared with several aims in view, for example, soil fertilization (a physico-chemical effect) by falling fruits, leaves and flowers. The human action is the effective deliberate action of selective cutting. Remnant trees exert effects of which people are aware and which are conscious aims of management. A number of other aims are expressed by farmers for the act of leaving some trees in the fields, such as protecting soil against erosion, protecting crops against strong winds and providing shade for crops and humans and soil moisture for crops. The act of leaving remnant trees cannot be separated from other, positive actions that achieve a good balance between felled trees and spared trees and produce the desired effects on field crop production

mentioned above. Techniques and particular tools exist to clear the undergrowth, to fell small trees and to prepare the cutting of large trees in such a way that they do not damage trees selected to remain.

To summarize, remnant trees in fields are an integral part of the whole process of agricultural production. Like soil preparation, plant and soil protection (Leroi-Gourhan 1945), and preparation of poisons for fishing and baits for hunting, the act of leaving remnant trees can be counted among the techniques of resource acquisition.

METHODOLOGY: SURVEYING REMNANT TREES

An 18-month investigation of swidden agriculture was conducted in Nkongmeyos village. During fieldwork, a total inventory of remnant trees was conducted in 21 fields totaling 10.38 ha. This constituted half of the active fields in this village for a given season. The inventory was composed of eight ***afup ngwan*** and 13 peanut fields (***afup owono***), seven of which were directly successional ***afup ngwan*** and six of which had been directly planted after removal of secondary forest. For each of these fields the following parameters were noted: the means used to clear it (axes and/or chain saw), the age of the forest that was cleared, and the surface area of the field. All trees found in the fields were included in the study; they were identified to species (when possible), their height and position in the field (edge or central position) were recorded, and the hardness of wood (hard, medium-hard, soft) was noted during my observations of tree felling which were then confirmed for most species by tropical forestry guide book (CTFT 1976). Interviews with villagers and observations of farmer activities in fields and fallows were conducted to understand why they retained some trees in the fields. For the dependent variables, Kruskal-Wallis one-way non-parametric analysis of variance (SAS 1996) was used to compare means and to test effects on the tree density variables. Student's t-tests were done to compare means two by two.

PROTECTED TREES IN THE FIELDS: HOW MANY AND WHICH ONES?

A total of 355 trees, belonging to at least 67 species and 27 families, were found in the 21 sampled fields (Appendix 1). Of the trees sampled, 54 were hard-wooded, 53 had medium-hard wood and 241 were soft-wooded (Appendix 1). The number of species is probably an underestimate, because several undetermined species of species-rich genera (e.g., *Ficus,* Moraceae) were not included. The distribution of individual trees according to position in the field (peripheral or center) and among height classes is shown in Table 1. The three most frequent species in the sample (*Ceiba pentandra, Triplochiton scleroxylon,* and *Terminalia superba*), all soft-wooded, together accounted for about one-third of all trees. Nine other species, accounting for about one-third of the total number of trees, were each represented by at least 10 individuals. The remaining one-third of the total number of trees were represented by 55 species, each of which was represented by fewer than 10 individuals (Figure 2).

Ntumu traditions include many examples of protective behavior towards

TABLE 1.—Total number of individual trees sampled in the 21 fields (10.38 ha) classified according to position in the field and to height classes (m).

	Position in the field		Height (m)		
	Peripheral	Center	≥30	30 > *x* > 15	≤15
n individual trees	185	167	231	101	20
Totals	352		352		

trees, but in many cases socioeconomic and ecological considerations may influence decisions to spare or not to spare trees in fields. Labor availability for felling is perhaps an important factor influencing the number and the type of trees left in fields. An old or very young person or a widow with only young children may not be able to clear undesirable medium-sized or large trees, or such individuals may select sites with only small, soft-wooded trees which will thus contain few remnant trees after clearing. Lack of time or money may also influence decisions about field choice and field clearing.

Field management practices are also constrained by weather conditions. A good swidden burn depends on timing the clearing so that slashed vegetation is dry before the arrival of the first rains of the wet season. Too much moisture in the slashed vegetation will reduce efficiency of the burn and result in decreased productivity. Thus, if rains arrive earlier than predicted, a farmer may have to burn before all undesired trees can be felled, in order to have an adequate burn before continued rains make burning completely impossible. In this situation

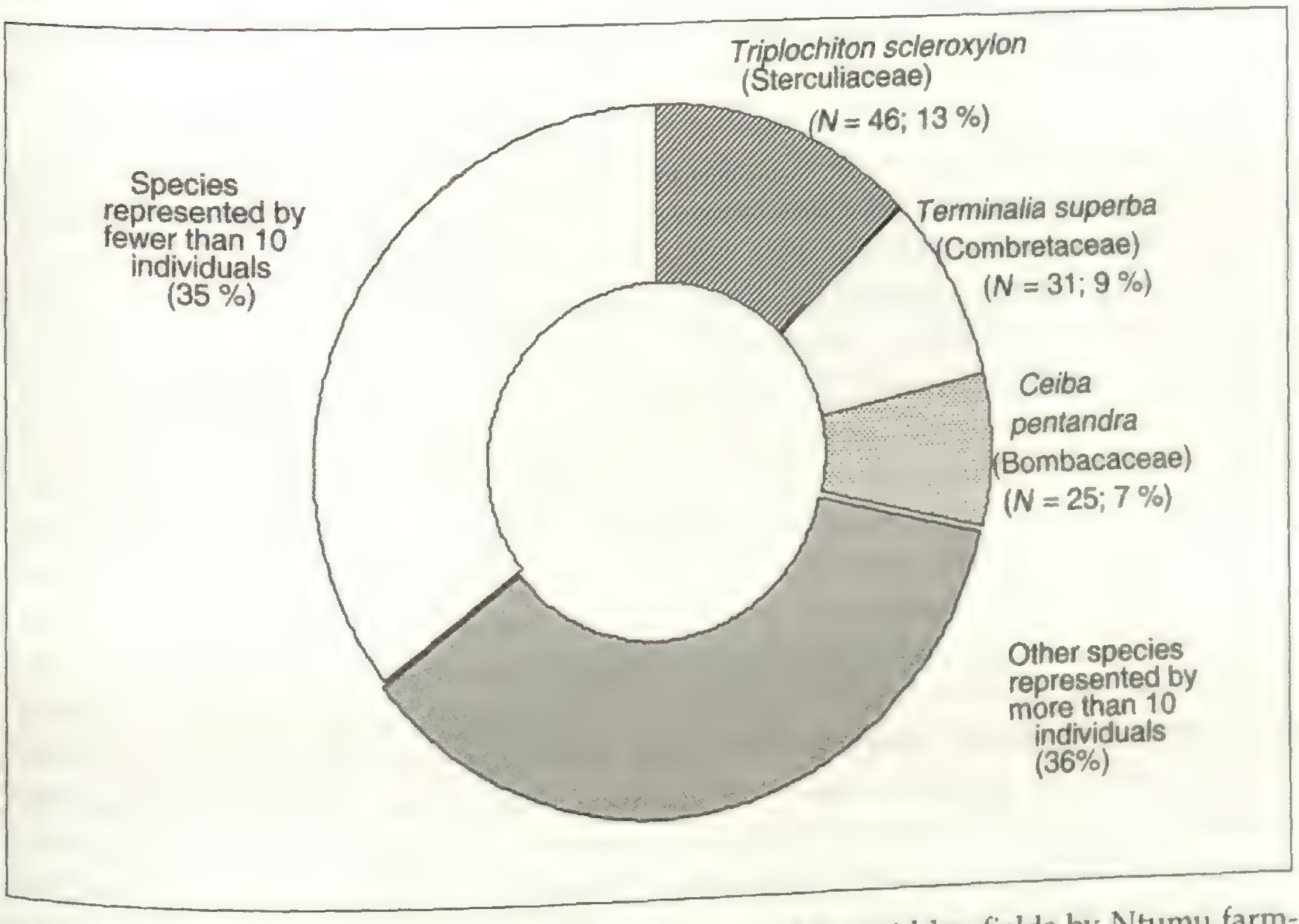


FIGURE 2.—Species composition of the trees protected in swidden fields by Ntumu farmers.

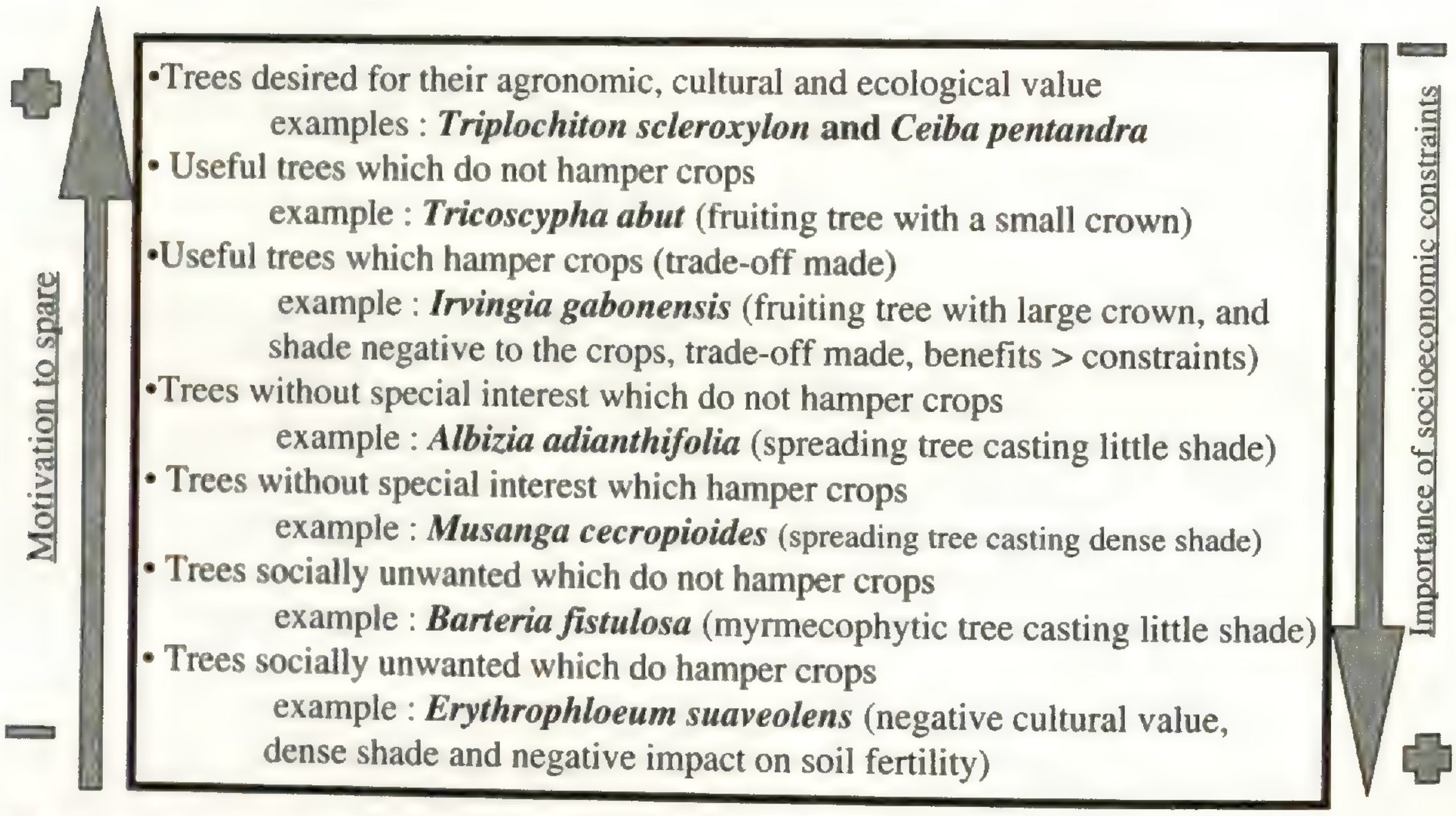

Orphan tree categories :
according to desirability and socioeconomic constraints
•Trees desired for their agronomic, cultural and ecological value
examples : Triplochiton scleroxylon and Ceiba pentandra
• Useful trees which do not hamper crops
example : Tricoscypha abut (fruiting tree with a small crown)
•Useful trees which hamper crops (trade-off made)
example : Irvingia gabonensis (fruiting tree with large crown, and shade negative to the crops, trade-off made, benefits > constraints)
•Trees without special interest which do not hamper crops
example : Albizia adianthifolia (spreading tree casting little shade)
• Trees without special interest which hamper crops
example : Musanga cecropioides (spreading tree casting dense shade)
• Trees socially unwanted which do not hamper crops
example : Barteria fistulosa (myrmecophytic tree casting little shade)
• Trees socially unwanted which do hamper crops
example : Erythrophloeum suaveolens (negative cultural value, dense shade and negative impact on soil fertility)
Motivation to spare
Importance of socioeconomic constraints

FIGURE 3.—Categories of "orphan" spared trees, according to Ntumu farmers, based on their desirability and on socio-economic constraints that affect clearing of the fields. The greater the desirability of the tree, the less other socio-economic factors intervene in felling decisions.

more trees are observed to be left in the fields. This could have an important impact on the crops, but in the farmer's judgment, an adequate burn is more important than the cutting of all undesired trees. The inverse situation can arise if the rains arrive even earlier, before a field has been cut and has had time to dry. The farmer may abandon the field and borrow another parcel from a relative. In many other situations where labor (or money to pay for labor) is lacking, Ntumu farmers must make compromise decisions regarding cutting of trees.

Figure 3 classifies different species represented among orphan trees according to the type and degree of incentive to spare (or cut) the tree, and the influence of socioeconomic constraints. In some cases, people must weigh the benefits (e.g., fruit or wood production) against the disadvantages (e.g., dense shade or cultural undesirability) associated with a particular tree. Some parts of the field are suitable for crop cultivation, whereas other parts may be principally useful in providing fruits, firewood, and other non-crop products. Figure 3 suggests that the more desirable the tree, the stronger the socioeconomic disadvantages must be to modify the decision to spare it. Conversely, the less a tree is desired, the stronger the socioeconomic disadvantages must be to modify a decision to cut it. Sometimes, the decision to cut or not to cut is based on other criteria. Some species are left standing because they interfere with crop cultivation when felled. For example, some much-branched large trees are very difficult to cut apart after felling. The bulky fallen crowns hamper cultivation by creating areas difficult to penetrate; difficult to weed, uncleared areas quickly become impenetrable and choked with vines. Such trees may be killed by girdling and/or burning, to pro-

voke the rapid fall of leaves and thus prevent them from casting too much shade. In this way, some unwanted species (e.g., *Pachypodanthium barteri* (Benth.) Hutch. and Dalz., Annonaceae) are eliminated without damage to the crop.

Many fields are established in old secondary forest. Here, clearing is easier because there are few large trees. These are mostly those spared in previous cultivation cycles and thus likely to be spared again.

WHY DO NTUMU FARMERS PRACTICE SELECTIVE CUTTING?

Selective cutting enhances fertility. In addition, some trees are more useful than others. Finally, trees are metaphors for people and so are part of the social world.

Management of Environmental Fertility on a Spatial Scale.—Some species of large trees, such as *Ceiba pentandra* (Bombacaceae), *Terminalia superba* (Combretaceae), *Triplochiton scleroxylon* (Sterculiaceae), *Chlorophora excelsa* (Welw.) Exell (Moraceae), are considered to be indicators of fertile soils. They are used by Ntumu farmers to guide the selection of a site for a future field. Individuals of these species are always present in the fields because of their high relative abundance in this area. The presence of some of these species could be more important than direct observation or perception of soil composition and structure in determining choice of site for a new field. Men and women think that falling leaves, flowers, fruits and animal excretions increase soil fertility beneath trees of these species in the fields, as well as in the forest. Ntumu farmers have noticed that soil fertility is quite heterogeneous in the forest and that this heterogeneity remains and may be even augmented after burning, because of the irregular distribution of ashes and trunks in the field (Nye and Greenland 1964). Leaving some standing trees in fields contributes to the management of soil fertility. Soil texture and color, or other readily evident soil traits, are in this environment not reliable indicators of fertility. The kind of trees growing on a site may be the most reliable indicators of potential fertility, both because certain trees grow on relatively favorable sites and because they create good sites by addition of litter. The practice of tree selection indicates how people could have adapted to a variable and unpredictable environment based on a deep knowledge of local ecology and soil potential (Allan 1972:217).

As is indicated by Ntumu technical vocabulary, the proper mix of light and shade is very important for field management. Very few adjectives are employed to designate different qualities of soils, but many nouns and adjectives designate the quality and quantity of light and shade (S. M. Carrière, unpublished data). Trees selected to remain in the fields must provide good shade (diffuse shade, but not too dense) for crops. Large, tall trees with high crowns casting diffuse shade that moves over the course of the day best meet this requirement. In a treeless field, leaves of some crops (such as plantains, macabo, taro, yams, sweet potatoes, and sometimes peanuts) would suffer from overheating and wilting, which could jeopardize production. Such crops are often planted beneath orphan trees to enjoy shade and fertility advantages. Another crucial point is that women, who usually take their infants with them into fields all day, need shady places to

keep them. Men and women also rest beneath orphan trees during pauses in work.

Ntumu farmers believe that shaded conditions beneath orphan trees, along with the intact root system, increase soil humidity. Also, remnant trees reduce wind velocity at ground level in fields, lessening the destruction of fragile crops such as cassava and plantain caused by the violent thunderstorms that occur during the transition between dry and rainy seasons. Thus, orphan trees contribute to the management of climatic risk. The strategy of field clearing is adopted in a way that assures an appropriate trade-off for each parameter that affects crop production, such as fertility, shade, and humidity. During tree felling, Ntumu farmers must take into account the number, position in the fields, height and shape, species, and density of the trees that are going to be spared. The position of the trees depends on the orientation of the fields and on the vegetation types and large trees located on field perimeters. The choice of site and orientation of future fields takes into account the sun's daily trajectory, which determines the position and trajectory of shade cast by each tree crown. For example, in the fields surveyed, no trees were left standing where trees bordering the field already provided shady conditions. In contrast, more tall trees were left in parts of fields where nothing else could provide good shade.

Management of Environmental Fertility on a Temporal Scale.—The crucial point in a swidden agricultural system is the management of the fallow period. Orphan trees are favored by the Ntumu because of their additional ability to facilitate regeneration of secondary regrowth. Ntumu farmers think (according to my interviews) that it is the growth of vegetation that restores potential soil fertility. In swidden agriculture the fallow period is crucial for the sustainability of the system. As did Hanunóo farmers in the Philippines (Conklin 1957), Ntumu farmers stated that the more trees in the fields, the shorter the fallow period. Selective felling seems to be an ancient practice to manage and favor forest succession in the fallows, the key point of such a system. These trees form the initial point of succession to forest (Yandji 1982; Denevan et al. 1984; Engel et al. 1984). Many studies have shown that remnant trees in pastures and fields increase seed rain beneath their crowns by attracting frugivorous animals which could disperse seeds of forest plants (Carrière et al. 2002b). Also, physical conditions beneath such trees favor growth of trees rather than herbaceous plants, thereby increasing the speed of succession (Carrière et al. 2002a). Beneath remnant trees in fallow fields, patches of regeneration could be observed, corresponding to the nucleation model of succession (Yarranton and Morrison 1974). During the fallow period remnant trees continue to fertilize the soil and contribute to establishing a good humus layer. After the fallow period the same trees will be spared during a renewed cycle of felling. This facilitates decisions about felling and ensures that the cultivators choose a parcel already tried and tested for its fertility.

The choice of species of tree left in fields depends also on other criteria of fertility management on a temporal scale. The land belongs to the first man who cleared it and this parcel will be transmitted to his children (Carrière 1999). Trees selected are thus chosen not only because of any immediate benefits which they might confer, but also because of the positive effects they have in later cycles of

cultivation by the farmer's descendants. According to the Ntumu, tree species often left in fields, such as *Ceiba pentandra, Terminalia superba, Triplochiton sclerox-ylon,* and *Chlorophora excelsa,* also add greatly to soil fertility when they die and decompose. The slow decomposition of the tree's trunk and branches provides a large quantity of mineral and organic nutrients, and according to the Ntumu yields will be greatly increased for many years through this process. For all these reasons, the long term strategy of Ntumu cultivators favors the choice of areas where such trees are common. The presence of spared trees influences floristic composition and the structure of regrowth vegetation (Carrière et al. 2002a). The number and identity of trees spared depends on the future use of the land. Thus, the cacao agroforests of the Ntumu began as new food-crop fields in which some species were favored in order to facilitate the creation of the agroforestry system. In parcels slated to become cocoa agroforests, more trees are spared, to provide the high, less open canopy of the agroforest. All useful trees are kept alive in order to concentrate resource-providing trees in the agroforest. After food-crop cultivation, the secondary regrowth is regularly cleaned to favor young trees of desirable species and to protect and encourage growth of cacao seedlings and saplings. Sparing trees during clearing allows farmers to manage the fertility and productivity of future cacao agroforests.

Trees Useful in Contexts Other than Agriculture.—One of the most common reasons given by Ntumu farmers, as well as by many other rainforest swidden farmers, to explain why they leave remnant trees is their utility in non-agricultural aspects of the production system (Conklin 1957; Dove 1985; Posey 1985; Bahuchet and De Maret 1993; Dounias 1993; Warner 1995; Ellen 1996; Carrière 1999). As shown in Table 2, they may provide edible fruits, ornamental flowers, or plant organs to prepare medicines. Their seeds may be used to prepare sauces or to provide playing pieces for games. Other species provide latex or resin, used to light fires, and toxic sap used in fishing poisons. Some species when fruiting attract many animals and are used as favorite hunting sites. Other species are hosts for edible caterpillars. Many species supply firewood and timber and other construction materials (planks, laths, posts, mortars, pestles, dugouts, canoes . . .). All of these trees are not necessarily used during the current cycle of cultivation but represent a standing, living capital that can be used later. Remnant trees in fields and fallows constitute a continuously available reserve of wood and they can be sold to pay for unpredictable future needs, such as school supplies, health care and cash crop cultivation (seeds, fertilizer, etc.). Field management includes taking care of this capital. The orphan trees contribute to the Ntumu subsistence strategy, which is based on their cosmogony of moderate use of nature by carefully con-trolling access to each wild resource (Bahuchet 1997).

Unwanted Tree Species.—Some tree species are unwanted by Ntumu as orphan trees and are felled when possible. Some are attractive to pest insects. Others, such as *Barteria fistulosa* Mast. (Passifloraceae), house very aggressive ants. This tree spe-cies is usually burnt alive during the burning of the fields. Felling *Barteria* is dangerous, because people are attacked by the tree's stinging ants. If a *B. fistulosa* tree survives the fire, the tree is left standing in the field and much care is taken to avoid it. In the past, this "magical" tree was used by elders to punish unfaithful

TABLE 2.—Uses of protected tree species in the fields by the Ntumu (authorities in Appendix 1).

n	Family Species	Local name	Anatomical part	Principal use
	Anacardiaceae			
5	*Tricoscypha abut*	***amvut***	fruit, bark	food, medicine
	Apocynaceae			
1	*Rauwolfia macrophylla*	***esombo***	bark, latex, fruit	medicine
1	*Funtumia elastica*	***ndama afan***	leaves, resin	resin, latex
	Bigoniaceae			
1	*Spathodea campanulata*	***evovon***	flowers	ornamental, medicine
	Bombacaeae			
25	*Ceiba pentandra*	***dum***	wood	firewood, construction
	Burseraceae			
6	*Canarium schweinfurthii*	***otou***	fruit, seed, latex	food, game, fire resin
1	*Dacryodes edulis*	***asa***	fruit	food
	Combretaceae			
31	*Terminalia superba*	***akom***	leaves, wood	edible caterpillars, firewood, construction
	Euphorbiaceae			
1	*Ricinodendron heudelotii*	***ezang***	seed	sauce
4	*Macaranga* sp.	***assas***	wood	firewood, construction
	Irvingiaceae			
19	*Irvingia gabonensis*	***andok afan***	fruit, seed	food, sauce
3	*Desbordesia glaucescens*	***alep***	bark, leaves	medicine
	Loganiaceae			
4	*Anthocleista schweinfurthii*	***elolom***	leaves, fruit	medicine
	Mimosaceae			
1	*Tetrapleura tetraptera*	***akpwaa***	fruit, seed	food, sauce
3	*Penthaclethra macrophylla*	***abe***	fruit	sauce
15	*Albizia adianthifolia*	***sayema***	leaves, bark, fruit	medicine
	Moraceae			
5	*Myrianthus arboreus*	***engokom***	fruit, crown	food, hunting site
15	*Musanga cecropioides*	***asseng***	fruit, wood	food, hunting site, firewood, construction
16	*Chlorophora excelsa*	***abang***	leaves, bark, wood	medicine, clothes,[1] firewood, construction

TABLE 2.—(continued)

n	Family Species	Local name	Anatomical part	Principal use
10	*Ficus* sp.	—	fruit, latex, bark, crown	food, medicine, clothes, hunting site
	Myristicaceae			
15	*Pycnanthus angolensis*	***eteng***	fruit, crown	hunting site, medicine
	Papilionaceae			
11	*Pterocarpus soyauxii*	***mbee***	bark, leaves, wood	medicine, firewood, construction
	Rutaceae			
3	*Zanthoxylum macrophyllum*	***olon***	bark, fruit, leaves	medicine, fishing poison
	Sterculiaceae			
13	*Eribroma oblongum*	***ndjong***	crown, bark, fruit, wood	hunting site, medicine, firewood
46	*Triplochiton scleroxylon*	***ayos***	leaves, wood	edible caterpillars, firewood, construction

[1] During historic times before "modern" cloth became widely available.

wives and thereby discourage subsequent offences. Women were attached naked to the tree for a night during which they were repeatedly stung.

Another tree, *Erythrophleum suaveolens* A. Chev. (Caesalpiniaceae), is undesirable because of its reputed capacity to sterilize the soil. The leaves and sap of this tree contain poisonous alkaloids and other substances which could have allelopathic effects on cultivated crops. Nevertheless, for several reasons this tree species is often observed in fields, where it usually occurs along the edge, to limit its impact (Appendix 1). This species was also used in the past as the 'truth tree'. Its powdered bark was inhaled by the accused person, whose reaction (no reaction or sneezing) determined the verdict. Even today, some people hesitate to cut it for fear of reprisals. A second reason this tree is often left standing is that its very hard wood prevents felling using axes, except by strong, young but experienced men. To face the different constraints of this species, Ntumu have created a rule. Before crop cultivation a present is made to the *E. suaveolens* tree (***afée elon***: ***afée*** 'present'; ***elon*** '*E. suaveolens*'), consisting of a few crops planted beneath these trees for a while. If the tree accepts the present, the crop will produce and the farmer can continue to establish the real plantation. If the present is not accepted, the farmer must go elsewhere to find a new site for his field.

Other species, such as *Pachypodanthium barteri* (which casts dense shade), are unwanted because they are known to discourage growth of crops.

Social Considerations.—Remnant trees in fields are termed ***ntolonboh' élé afup*** ('orphan'; 'tree'; 'field': 'orphan trees in the fields'), by the Ntumu because they have

been left alone, having lost all of their fellows during field clearing. The cutting of large trees, done by men only, is compared to a heroic, painful and dangerous warlike activity. "When a man is cutting the forest, he is engaged in warfare," as Laburthe-Tolra (1981) puts it for the Beti. Field clearing is considered the highest-risk activity of shifting cultivators (Conklin 1957; Dounias 1993; Carrière 1999). Among the Ntumu, the same sexual and behavioral prohibitions applied to hunting and war activities are also applied to the cutting of large trees (with axes or by chain saw). During the 'war-like act' of field clearing, some survivors are left standing in the fields. These become the orphans of the forest. As with orphan people in Ntumu society, orphan trees have a special social duty in recreating life. Among the Ntumu, orphaned people leave the familial house and build their own village. In Beti society some new lineages were created in this way (Laburthe-Tolra 1981), consistent with the value placed by the Beti on conquest of forest land and an out-migration strategy. Similarly, orphan trees in the fields are seen as contributors to forest regeneration and lose their orphan status when new trees grow to join them during the fallow period. The symbolic war between humans and forest has a double meaning. The first is to clear the forest and to win against the forest in order to achieve an action of which one can be proud. The second is to let the forest win the reconquest of the land and accept the lost battle. The respect of this kind of pact allows the farmer to return to the fallows to cultivate another time. In contrast, the intensification of cultivation can lead to the total destruction of soil potential. According to Dounias's analysis, humans have to reach a pact with the forest and accept the constraints of access (Dounias 1993).

Never, during 18 months of field work, did I observe fields cleared by Ntumu farmers that lacked remnant trees. Indeed, to the question, "Can you conceive of cutting all the trees during the clearing of the forest?" the Ntumu farmers answered, "never, it is an impossibility." Through this categorical answer, we perceive the crucial importance of this practice. As is often mentioned, many techniques and conceptions are learned without any masters or apprentices (Colleyn 1988). However, the strategy of felling is extremely complex and dangerous, and young farmers need to learn how to cut the trees and how to avoid the destruction of others. This training can take many years of working with an experienced person, such as a man's father. In fact, for several reasons that we develop below, Ntumu men and women choose their future fields based on the presence of some species of trees, which will be spared during field clearing. After choosing the field's location the cutting is planned. The farmer must take into account the positions of the crown of each tree, where the tree will fall, the presence or absence of lianas between the trees, and which trees are to be cut and which spared. Finally, he has to organize clearing so that it requires as little work as possible.

In Central Africa, native societies customarily plant trees or use existing trees to indicate boundaries and land ownership (Bahuchet and De Maret 1993). This is particularly the case with some rare species, such as *Baillonella toxisperma* Pierre (Sapotaceae) or *Guibourtia tessmannii* (Harms) Léonard (Caesalpiniaceae). In any case, all trees spared during clearing land for cultivation belong to the first cultivator. All use of these trees is reserved for the family of the owner, but trees can be sold or loaned for a period. In this case, compensation, whether monetary, a part of the harvest, or in kind, is fixed and required by the owner. Many orphan

trees in fields serve to indicate property limits and remain useful when farmers come back to clear an old fallow in regrowth where limits are no longer obvious.

Trees as Social Symbols.—In order to understand why Ntumu farmers exercise a certain kind of protective behavior towards trees, it is important to examine the system of thought embedded in the culture, the symbolic representation of trees in this system, and finally the history of the society. Techniques and conceptions of the world are reflected in collective representations and grounded in a particular ideological and symbolic system. These techniques and conceptions are learned, but without formal training. Among the Ntumu, many symbolic correspondences exist between characteristics of people (such as age or gender) and characteristics of trees. We must thus examine the symbolic and religious functions of trees (Bahuchet 1997). The following examples are very indicative.

In Ntumu society, as well as in many other lineage societies of central Africa, there is no central authority. Power belongs collectively to the elders of the lineage. Thus, the system of values attributes particular value to age. To be old is to be more sacred. Old persons are respected and have extrasensory faculties. Elders are imagined to be in contact with the beyond. After their death, the respect offered old persons is transferred to an ancestor cult (Colleyn 1988). In such a society, old trees may be respected as are the old persons. During cutting and burning of the fields, almost all of the old large trees are spared. Only specifically undesirable trees are sometimes destroyed. The density of large trees in the forest is low, so clearing the forest corresponds to cutting the layers of medium and small trees. This allows much needed light for crop growth to reach ground level without cutting the old respected trees.

The bark of *Chlorophora excelsa* was used to prepare bark cloth, made and worn by men. Bark of this tree is important in the ancestral symbolism of the Beti (Laburthe-Tolra 1981), including the Ntumu. This species is a majestic, large forest tree with an erect trunk; it produces a milky white latex, symbolically associated with semen and hence fertility. The fibers of the bark were in permanent contact with the men's sexual organs in order to transmit to the people the characteristics of the trees and to receive the beneficial influence of the ancestors on sexual fertility (Laburthe-Tolra 1981).

Canarium schweinfurthii is another species of great social importance. The resin produced by this species (***otou*** '*C. schweinfurthii* resin') is used by the Ntumu to create and maintain the fire in a village household, in the fields, and in forest encampments during hunting and fishing expeditions. The symbolic aspects of this resin are very important in understanding why it is inconceivable to cut such a useful and protective tree. The soot of the resin "***otou***" is rubbed on skin scarifications in order to produce blue tattoo-like decorations. At the beginning of this century this practice was very important in Ntumu populations in the Ntem valley (Tsala 1958, 1973). These tattoos were made when boys were circumcised, to make them sexually attractive and to show the power of the owner. The tattoos were required for recognition by the boy's family, to attract the love of living humans, and to frighten malevolent beings (Laburthe-Tolra 1981). In fact the resin of this tree was burnt during rituals to produce an incense considered to be sweet to the ancestors. The resin was also used to fuel lamps during rituals. A family

chief could burn the ***otou*** when troubles appeared because ***otou*** could chase out witches. Protection was required during the making of tattoos and ***otou*** incense was used to light and protect forest encampments against malevolent spirits during hunting or fishing expeditions.

Ceiba pentandra assumes the same sexual connotations as *Chlorophora excelsa,* because of its majestic erect trunk. The Ntumu local name of this species, ***dum*** (Carrière 1999), recalls glory and celebrity (***dum*** 'glory', 'celebrity') (Laburthe-Tolra 1981). The base of this tree, usually with massive buttresses, was used as a sepulcher where the dead were buried, to maintain among the ancestors the properties of the trees: glory and power. It was also mentioned by Dove (1985: 125–126) that trees with sacred value include those growing in ground in which human remains have been interred.

Finally, the case of *Triplochiton scleroxylon* is interesting because it shows the correspondence of the domain of nature and cultivation with the psychological characteristics of humans. One of the Ntumu (and Beti) local names of this tree is ***edjidjin,*** which means a good and beautiful light shade that is considered to be the best shade for cultivated plants. It is due to the shape and the height of the crown of this species. This word is also used to refer to the character of a good person, especially someone calm and dignified who does not create problems for others.

THE IMPACT OF CHAIN SAWS: A CLUE THAT SPARING REMNANT TREES IS A DELIBERATE AGRICULTURAL PRACTICE

In many studies on native swidden agriculture, sparing of isolated trees is ascribed to laziness, to the lack of means for cutting very hard-wooded trees, which often possess massive buttresses, or to socioeconomic difficulties in procuring tools or labor (De Rouw 1991; Dounias 1993; De Wachter 1997; Rösler 1997). But such an interpretation may reflect the lack of studies focused on this practice and on the reasons why selective cutting is done. At present, with the recent extension of some "modern" tools such as the chain saw (De Rouw 1991; Dounias 1993; Ellen 1997; Joiris 1997) all over the tropical world, we have an opportunity to examine this question. What remains in an Ntumu field when a chain saw is available for clearing? Are the harder-wooded trees more common in the axe-cleared fields? Villagers of Nkongmeyos began to use chain saws about five years ago, though axes continue to be the most widespread tool used to clear the forest. If remnant trees are left because people lack easy means to clear them, the availability of chain saws should result in a important decrease in the number of trees left. In particular, the number of hard-wooded trees left standing should be lower. On the other hand, if our hypothesis that sparing remnant trees in the fields is a deliberate practice is correct, then the use of the chain saw should not affect the practice of selective cutting. The use of the chain saw show allow us to examine the impact of the chain saw on the number of remnant trees and among them the number of hard-wooded trees left in the fields.

Mean Density of Trees in the Fields.—In the *C. mannii* fields ***afup ngwan*** (N = 8 fields; 3 cleared by axe, 5 cleared by chain saw), the results showed that there

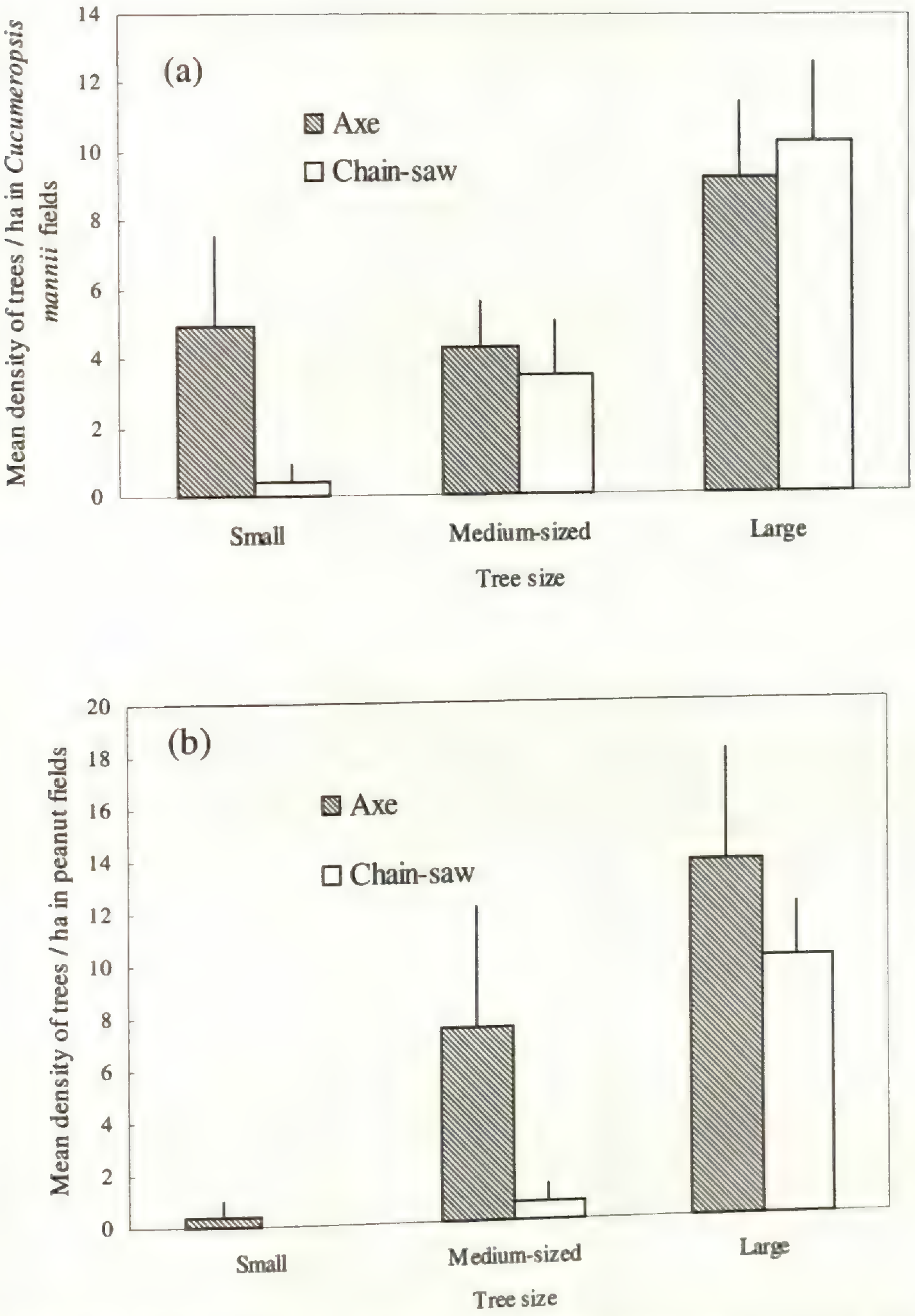


FIGURE 4.—(a) Mean density of trees/ha in *C. mannii* fields, and (b) mean density of trees/ha in peanut fields for different tree size classes depending on the method of clearing, by axe or by chain saw. Bars are standard deviations.

was not a significant difference in density of (1) large trees ($F_{1,6} = 0.23$; $P>0.05$; Figure 4a) and (2) medium-sized trees ($F_{1,6} = 0.24$; $P>0.05$; Figure 4a) between fields cleared with axes or with chain saws. Density of small trees was lower in chain saw cleared fields but this concerns only a small percentage (6%) of all trees left. Ntumu farmers say that fields are made more "clean" when a chain saw is used because when cutting is done with axes, some small intruder trees are left standing to save the time that would be lost in cutting them. Another point

showed that in almost all fields cleared by chain saw, work was done by people hired from other villages or households, who find it easier to cut everything than to pay attention to each small tree. Despite small sample size that has been available, chain saws appear to have an impact on the mean density of small trees.

If we consider peanut fields (N = 13 fields; 8 cleared by axe, 5 cleared by chain saw) only, the results were quite different (Figure 4b) but this was not directly and solely the consequence of the means of clearing. For all size categories of trees, density of remaining trees was not significantly higher for both medium-sized ($F_{1,11} = 3.00$; $P > 0.05$) and large trees ($F_{1,11} = 0.78$; $P > 0.05$) when clearing was done with axes than with chain saw, but for both size classes there was a trend in this direction (Figure 4b). Though increasing the sample size would have a probability of producing a significant difference, several factors may combine to account for this trend, and for the apparent difference between peanut fields and *C. mannii* fields. First, for both kind of fields, all of the fields cleared directly from young secondary forests were cleared with axes. All of the peanut fields mentioned as "cleared by chain saw" had in fact directly succeeded a *C. mannii* field that had been created by clearing primary or mature secondary forest and cleared with a chain saw (there was not a second clearing between harvest of *C. mannii* and sowing of peanuts). *C. mannii* fields are each about 1 ha and peanut fields about 0.25 ha. Peanuts require sunlight to grow and produce well. Medium-sized trees, whose low crowns produce denser shade than the high crowns of large trees, have particularly negative effects on the peanut crop. Women could thus in this case choose an area of low tree density in the *C. mannii* harvested field to establish a peanut field. This choice introduced a bias in the estimation of tree density in the peanut fields that succeeded *C. mannii* fields. Fields of *C. mannii* remain the only ones that were cleared and cultivated in their entirety. For this reason peanut fields cleared directly from secondary forest are not directly comparable with those located in the less shaded part of *C. mannii* fields. Thus fields of *C. mannii* remain the most appropriate for comparing the impact of the chain saw on the decisions made by the farmer to keep some trees in the fields. The second point that may explain the higher density of medium-sized and large trees in my sample of axe-cleared peanut fields concerns the particular clearing conditions of two of these fields which had been cleared with an axe by widows helped by their children. The density of trees in these two fields (40 trees/ha and 36.7 trees/ha) are not representative of the whole sample of axe-cleared fields (mean density = 21.0 ± 12). The mean density of trees without these two fields is lower (mean density = 16.7 trees/ha ± 8.9).

Mean Density of Trees and Hardness of Wood.—In the fields sampled (N = 21), the results of Student's t-tests showed that for both medium-sized and large trees, no class of wood hardness showed a significant difference in density between fields cleared with an axe or with a chain saw (Figure 5). Very hard-wooded and medium-hard-wooded large tree species (such as *Lophira alata, Chlorophora excelsa, Eribroma oblungum, Desbordesia glaucescens, Erythrophloeum ivorense, Klainedoxa gabonensis,* and *Petersianthus macrocarpum*) are less important in this area than soft-wooded species because the most frequent species in the cleared forests are soft-wooded pioneer species (such as *Ceiba pentandra, Pycnanthus angolensis, Terminalia*

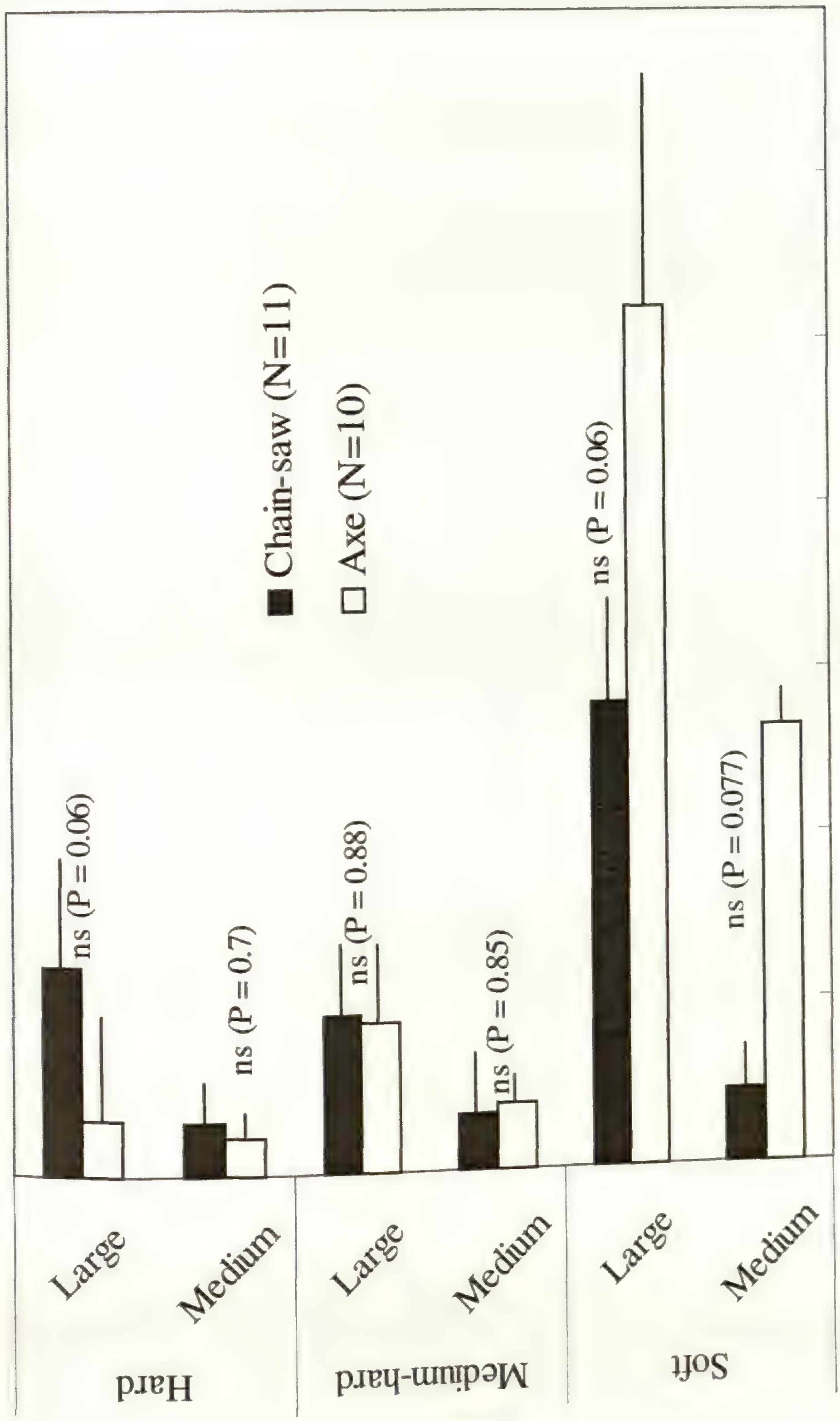


FIGURE 5.—Mean density of trees/ha in Ntumu fields for different tree size classes and wood hardness classes depending on the method of clearing, by axe or by chain saw. Bars are standard deviations.

superba, and *Triplochiton scleroxylon*). Although there was not a statistically significant difference, two tendencies can be observed for hard-wooded and soft-wooded classes. The negative impact of chain saws on the density of hard-wooded trees is not demonstrated (mean density of hard-wood was higher in fields cleared with a chain saw); but the insufficient statistical power (small sample size, large variance), and the not real absence of an effect, may explain the non-significance of results. The tendency observed could be explained, however, by the fact that most of the fields sampled that were cleared from old secondary forest (where hard-wooded species were most frequent) were cleared with a chain saw. This tendency could suggest that the chain saw could have influenced the choice of forest type to be cleared and thus have an impact on the percentage of primary forest clearing every year. With the coexistence of the two methods of clearing (axe and chain saw) it is difficult to determine whether farmers try to get a chain saw when they have to clear old secondary or mature forest, or whether they decide to clear this kind of forest when they know that a chain saw is available.

As for the mean density of trees in the peanut fields, the tendency for higher density of soft-wooded large and medium-sized trees in fields that were cleared with axes is mainly due to: (1) the atypical high density in the two fields that were axe-cleared by widows and (2) the bias introduced by the fact that women can choose some of their fields in the less shaded part of the *C. mannii* fields (see below). If we omit these two atypical fields in the statistical analysis the Student's t-tests are not significant with higher probabilities ($P = 0.2$ for Soft-Large class and $P = 0.16$ for Soft-Medium-Sized class of Figure 5).

The chain saw is seen by anthropologists to be a baneful influence partly responsible for the erosion of sustainable long standing practices and knowledge (Ellen 1997) and responsible for new types of radical clearing. In the case examined here, however, the chain saw appears to have an impact on the making of decisions about which and how many trees to keep in the fields. Chain saw clearing is often done by hired people, and they cut small trees rather than pay attention to each one as does the owner. Social relations between trees and the people cutting them have begun to change. However, even when tools, labor and money to buy fuel are available, Ntumu farmers continue to leave trees in the fields. But the availability of chain saws could also have a great influence on the type of forest chosen for clearing because it is easier to clear a primary forest with a chain saw than with an axe, and parcels cleared from primary forest are more productive, especially for the important man's crop, *C. mannii.* Although the chain saw does result in changes, even with chain saw cleared fields there are still many remnant trees. Selective cutting is an intrinsic part of the techniques used in this swidden agricultural system. This conclusion runs counter to the widespread belief, also criticized by many other authors (e.g., Condominas 1997), that swidden farmers are lazy, unsettled and environmentally ignorant. It also shows that the introduction of new powerful tools, unaccompanied by any major social and economic change, does not necessarily fundamentally alter the way people manipulate the environment. But the changes we observed suggest that the selective cutting compromise remains fragile.

CONCLUSION

Sparing remnant trees in the fields is an ancient agricultural practice in traditional Ntumu society. 'Orphan' trees allow Ntumu and probably many other populations of traditional farmers to manage the fertility and productivity of the environment in space and time. It is remarkable to see that the roots of agroforestry management practices can be found in traditional agricultural systems.

We can postulate that if the cutting compromise between needs of men's crops and those of women's crops exists, it is due to the very great diversity of crops cultivated, each with its own particular ecological needs. Equilibrium can exist only if various crops co-occur in the same fields. The cutting strategy in field clearing must satisfy the ecological conditions required by each of the crops co-occurring in space and succeeding in time. Furthermore, remnant trees contribute to facilitating forest regeneration in fallows. The practice of sparing trees reflects a good understanding of ecological processes such as maintenance of soil fertility and forest regeneration. This practical knowledge of forest ecology contributes to adaptation of agricultural practices and techniques to the rain forest environment.

Along with the physical constraints and possibilities presented by the material world, the social representation of this technology also influences the actual outcomes (Lemonnier 1992). Ethnobotanical knowledge and practice, must, therefore, be understood contextually, and recognized as intrinsically variable and subject to change (Ellen 1996). Like the Ntumu, many other populations have an important role in shaping the landscape and thereby affecting how floristic composition varies in space and time. Many people of the rain forests selectively fell trees, protecting valued species in a sufficiently systematic way that one can speak of "rainforest management" (Ellen 1996:463). The Ntumu practice of preferentially sparing particular species, especially those characterising old secondary forests, such as *Ceiba pentandra, Triplochiton scleroxylon* and *Terminalia superba,* has increased the density and distribution of such species over many centuries. All of these trees are light-demanding pioneers that persist in the forest canopy. A particular human cultural action, the selective sparing of these trees, and a natural ecological process, the favoring of these light-demanding species in swidden clearings (Letouzey 1985), have the same effect on the forest. Both increase the abundance of these culturally valued and useful species in the forests of this area. Ironically, the long-term sustainable strategy of swidden-farmers like the Ntumu may be responsible for the abundance of valued timber trees such as *T. scleroxylon* and *T. superba,* which makes their territory a tempting target for unsustainable levels of commercial logging.

The practice of preserving certain trees is culturally determined, and subject to change depending on factors such as market forces, population pressure and social change. Ntumu originating from Equatorial Guinea have migrated into the Ntem valley. These newcomers have different practices from the indigenous Ntumu of southern Cameroon. They keep fewer trees in their fields because in Equatorial Guinea fields are larger and the economy is more specialized towards cash-oriented production. Moreover, the floristic composition of forest in their area of origin is different and the culturally valuable species are different. These newcomers do not preferentially spare *Triplochiton scleroxylon,* because in Equatorial

Guinea this species is rare and not especially valued. These observations indicate that cultural, social and economic factors are very important in determining practices concerning remnant trees and their impact on the forest. De Rouw (1991) offers other examples of differences between foreign and native practices in Côte d'Ivoire. The native Oubi, who know their own forest very well, keep some trees in their rice fields, while the foreign Baoulé, migrants and colonizers, generally kill all the trees in the fields during clearing. It is thus impossible to understand local attitudes without integrating the historical dimension. Local people, on the whole, respect knowledge gained from past experience. However, many traditional swidden farmers around the world do not leave remnant trees in their fields. This may reflect great variation in cultural free will, history of cultivation systems, and environment.

Many populations of swidden farmers have independently created associations between trees and crops, now called "agroforestry systems," which reduce the risk of declining soil fertility in the face of increasing population pressure. But this behavior is not always reported as obvious. In traditional Ntumu society spared trees are undeniably part of the crop cultivation system, but this could be subject to change. In this currently stable situation the impact of the chain saw already exists. It is clear, that a shift in subsistence strategy could drive farmers to use tools such as the chain saw to produce larger fields for the production of cash crops. Many studies of peri-urban villages and large towns have shown that the intensification of cultivation leads to loss of crop diversity (Santoir 1992). This kind of specialization of production driven by commercialisation may contribute to the erosion not only of crop diversity but also of those traditional agricultural practices and knowledge associated with crop diversity and required for its maintenance (Ellen 1997). Crop diversity in space and time, and an agricultural strategy oriented to this diversity, are the guarantors of a sustainable dynamic equilibrium between the forest and human populations and of the conservation of the adapted ancestral practices.

ACKNOWLEDGMENTS

This research was funded by the programme "Avenir des Peuples des Forêts Tropicales" (APFT) of the European Commission (DG VIII). Funding included a fellowship (to SC) administered by ORSTOM (now IRD), the French government organization for research in cooperation applied to development. Edmond Dounias, Francis Menye Menene, Nicolas Alo'o Eyéné and Serge Cogels provided invaluable help during the field work and helped in planning the vegetation sampling and in data analysis. Serge Bahuchet, Doyle McKey, Roy Ellen, Laura Rival, Edmond Dounias, Christian Leclerc and anonymous reviewers are thanked for their advices during field work and their critical comments on the manuscript. Finally I thank Martin Buchsenschutz for his very useful advice on calculating surface area of fields.

REFERENCES CITED

Allan, W. 1972. Ecology, techniques and settlement patterns. In *Man, Settlement and Urbanism,* eds. P. J. Ucko, R. Tringham, and G. W. Dimbleby, pp. 211–226. Duckworth, London.

Anonymous. 1990. Précipitations journalières de 1973 à 1980. Comité Interafricain d'Etudes Hydrauliques, Agence pour la Sécurité de la Navigation, IRD (Ex-ORSTOM), Ministère de la Coop-

ération et du Développement, République du Cameroun.
Bahuchet, S. 1997. Un style de vie en voie de mutation: considérations sur les peuples des forêts denses humides. *Civilisation* 44:16–31.
Bahuchet, S. and P. De Maret. 1993. Situation des populations indigènes des forêts denses et humides. Report written for DG VIII of the European Commission, Luxembourg.
Beets, W. C. 1990. *Raising and Sustaining Productivity of Smallholder Farming Systems in the Tropics.* AgBé Publishing, Alkmaar, Holland.
Belsky, A. J. and C. D. Canham. 1994. Forest gap and isolated savanna trees: an application of patch dynamics in two ecosystems. *Bioscience* 44:77–84.
Benneh, G. 1972. Systems of agriculture in tropical Africa. *Economic Geography* 48: 244–257.
Boserup, E. 1965. *The Conditions for Agricultural Growth: The Economics of Agrarian Change under Population Pressure.* George Allen and Unwin, London.
Buschbacher, R., C. Uhl, and E. A. S. Serrao. 1988. Abandoned pastures in eastern Amazonia. II. Nutrient stocks in the soil and vegetation. *Journal of Ecology* 76: 682–699.
Cardoso Da Silva, J. M. C., C. Uhl, and G. Murray. 1996. Plant succession, landscape management, and the ecology of frugivorous birds in abandoned Amazonian pastures. *Conservation Biology* 10: 491–503.
Carrière, Stéphanie M. 1999. Les orphelins de la forêt: influence de l'agriculture sur brûlis des Ntumu et des pratiques agricoles associées sur la dynamique forestière du sud-Cameroun. Ph.D. Dissertation (Tropical Ecology), University of Montpellier II, Sciences et Techniques du Languedoc, France.
Carrière, Stéphanie M., P. Letourmy, and D. B. McKey. 2002a. Effects of isolated trees in fallows on diversity and structure of forest regrowth in a slash and burn agricultural system in southern Cameroon. *Journal of Tropical Ecology* 18: 375–396.
Carrière, Stéphanie M., M. Andre, P. Letourmy, I. Olivier, and D. B. McKey. 2002b. Seed rain beneath remnant trees in a slash and burn agricultural system in southern Cameroon. *Journal of Tropical Ecology* 18: 353–374.
Colleyn, J.-P. 1988. *Eléments d'anthropologie sociale et culturelle.* ULB Publishers, Brussels.
Condominas, G. 1997. Essartage et confusionnisme: à propos des Mnong Gar du Viêtnam central. *Civilisation* 44:228–237.
Conklin, H. C. 1957. Hanunoo agriculture: a report on an integral system of shifting cultivation in the Philippines. *FAO Forestry Development,* Paper No. 12, pp. 1–167. Rome.
CTFT. 1976. Mémento du Forestier. Techniques rurales en Afrique, ed. Ministère de la Coopération et du Développement. Centre Technique Forestier Tropical, Collections "Techniques rurales en Afrique," Nogent-sur-Marne, France.
De Rouw, Anneke. 1991. *Rice, Weeds and Shifting Cultivation in a Tropical Rain Forest. A Study of Vegetation Dynamics.* Agricultural University, Wageningen.
De Wachter, P. 1997. Economie et impact spatial de l'agriculture itinérante Badjoué (Sud Cameroun). *Civilisation* 44:62–93.
Denevan, W. M., J. M. Treacy, J. B. Alcorn, C. Padoch, J. Denslow, and S. F. Paitan. 1984. Indigenous agroforestry in the Peruvian Amazon: Bora Indian management of swidden fallows. *Interciencia* 9: 346–357.
Dounias, Edmond. 1993. Dynamique et gestions différentielles du système de production à dominante agricole des Mvae du sud-Cameroun forestier. Ph.D. Dissertation (Tropical Ecology), University of Montpellier II, Sciences et Techniques du Languedoc, France.
Dove, R. D. 1985. *Swidden Agriculture in Indonesia: The Subsistence Strategies of the Kalimantan Kantu'.* New Babylon, Studies in the Social Sciences. Mouton Publishers, Berlin, New York, Amsterdam.
Ellen, Roy. 1994. Modes of subsistence: hunting and gathering to agriculture and pastoralism. In *Companion Encyclopaedia of Anthropology: Humanity, Culture and Social Life,* ed. T. Ingold, pp. 197–225. Routledge, London.
———. 1996. *Putting Plants in Their Place: Anthropological Approaches to Understanding the Ethnobotanical Knowledge of Rainforest Populations.* Tropical Rainforest Research—Current Issues, Kluwer Ac-

ademic Publishers, Dordrecht, Netherlands.
———. 1997. The human consequences of deforestation in the Moluccas. *Civilisation* 44:176–193.
———. 1998. Indigenous knowledge of the rain forest: perception, extraction and conservation. In *Human Activities and the Tropical Rainforest,* ed. Bernard K. Maloney, pp. 87–99. Kluwer Academic Publishers, Dordrecht, Netherlands.
Engel, A., J. Karimu, M. Calderon-Hagemann, W. Herbinger, W. Keipp, J. Knoth, G. Schoop, and H. Weise. 1984. *Promoting Smallholder Cropping System in Sierra Leone.* Center For Advance Training in Agricultural Development. Institute of Socio-Economics of Agricultural Development. Technical University, Berlin.
Fosbrooke, H. A. 1974. Aspects socioéconomiques de la culture itinérante. L'agriculture itinérante et la conservation des sols en Afrique. *Bulletin pédologique de la FAO,* No. 24, pp. 144–150. Rome.
Geertz, C. 1963. *Agricultural Involution: The Process of Ecological Change in Indonesia.* University of California Press, Berkeley.
Gliessman, S. R. 1985. Economic and ecological factors in designing and managing sustainable agrosystems. In *Sustainable Agriculture and Integrated Farming Systems,* eds. T. C. Edens, C. Fridgen, and S. L. E. Battenfield, pp. 56–63. Michigan State University Press, East Lansing.
Grenand, F. and C. Haxaire. 1977. Monographie d'un abattis Wayapi. *Journal d'agriculture traditionnelle et de botanique appliquée* 24:285–310.
Grenand, Pierre. 1979. Commentaires à propos d'un abattis Wayapi (Guyane Française). *Cahiers de l'IRD (ex-O.R.S.T.O.M), Série sciences humaines* 16: 299–303.
Guevara, S., J. Meave, P. Moreno-Casasola, and J. Laborde. 1992. Floristic composition and structure of vegetation under isolated trees in neotropical pastures. *Journal of Vegetation Science* 3:655–664.
Guevara, S., S. E. Purata, and E. Van der Maarel. 1986. The role of remnant forest trees in tropical secondary succession. *Vegetatio* 66:77–84.
Guthrie, M. 1948. *The Classification of the Bantu Languages.* London.
Janzen, D. H. 1988. Management of habitat fragments in a tropical dry forest: growth. *Annals of the Missouri Botanical Garden* 75:105–116.
Johnson, A. 1983. Machiguenga gardens. Adaptative responses of Native Amazonians. In *Studies in Anthropology,* eds. R. B. Hames and W. T. Vickers. Academic Press, New York.
Joiris, Daou V. 1997. L'Afrique équatoriale: introduction régionale. *Civilisation* 44: 38–43.
Kang, B. T., G. F. Wilson and T. L. Lawson. 1984. *Alley Cropping: A Stable Alternative to Shifting Cultivation.* International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.
Laburthe-Tolra, Philippe. 1981. Les seigneurs de la forêt: essai sur le passé historique, l'organisation sociale et les normes éthiques des anciens Beti du Cameroun. *Publications de la Sorbonne, Série ns recherche* No. 48. Paris.
Lemonnier, Pierre. 1992. *Elements for an Anthropology of Technology.* Anthropological Papers 88, University of Michigan Museum of Anthropology. Ann Arbor.
Leroi-Gourhan, Andre. 1945. *Evolution et techniques: milieu et techniques.* Albin Michel edition, Paris (reprinted 1973).
Letouzey, R. 1985. Notice de la carte phytogéographique du Cameroun au 1: 500 000 (1985). Domaine de la forêt dense humide toujours verte, pp. 95–142. Institut de la Carte Internationale de la Végétation, Toulouse, France.
Linares, O. F. 1976. "Garden hunting" in the American tropics. *Human Ecology* 4: 331–349.
McClanahan, T. R. and R. W. Wolfe. 1987. Dispersal of ornithochorous seeds from forest edges in central Florida. *Vegetatio* 71:107–112.
———. 1993. Accelerating forest succession in a fragmented landscape: the role of birds and perches. *Conservation Biology* 7:279–288.
McDonnell, M. J. and E. W. Stiles. 1983. The structural complexity of the old field vegetation and the recruitment of bird-dispersed plant species. *Oecologia* 56: 109–116.
Mauss, M. 1935. Les techniques du corps. *Journal de psychologie* 32(3–4):271–293.

Nepstad, D., C. Uhl, A. Pereira, and J. M. Cardoso Da Silva. 1996. A comparative study of tree establishment in abandoned pasture and mature forest of eastern Amazonia. *Oikos* 76:25–39.

Nepstad, D., C. Uhl, and E. A. S. Serrao. 1991. Recuperation of a degraded Amazonian landscape: forest recovery and agricultural restoration. *Ambio* 20:248–255.

Nye, P. H. and D. J. Greenland. 1964. Changes in the soil after clearing tropical rainforest. *Plant and Soil* 21:101–112.

Posey, Darrell. A. 1985. Indigenous management of tropical forest ecosystems: the case of the Kayapo Indians of the Brazilian Amazon. *Agroforestry Systems* 3:139–158.

Rambo, A. T. 1985. *Primitive Polluters: Semang Impact on the Malaysian Tropical Rain Forest Ecosystem.* Anthropological Papers 76, University of Michigan Museum of Anthropology. Ann Arbor.

Rösler, M. 1997. Shifting cultivation in the Ituri Forest (Haut-Zaire): colonial intervention, present situation, economic and ecological prospects. *Civilisation* 44: 44–61.

Sanchez, P. 1976. *Properties and Management of Soils in the Tropics.* John Wiley and Sons, New York.

Santoir, Christian. 1992. *Sous l'empire du cacao.* Etude diachronique de deux terroirs camerounais. À travers champs, IRD (ex-ORSTOM), Paris.

SAS. 1996. *SAS/STAT User's Guide,* Release 6.12. SAS Institute, Cary, North Carolina.

Sirois, M. C., H. A. Margolis, and C. Camire. 1998. Influence of remnant trees on nutrients and fallow biomass in slash and burn agroecosystems in Guinea. *Agroforestry Systems* 40:227–246.

Suchel, J. B. 1972. *La répartition et les régimes pluviométriques au Cameroun.* CEGET/CNRS, Bordeaux.

Tsala, A. T. 1958. *Moeurs et coutumes des Ewondo.* Etudes Camerounaises, no. 56.

———. 1973. *Mille et un proverbes Beti: la société beti à travers ses proverbes.* Yaoundé, Cameroun.

Viera, I. C. G., C. Uhl, and D. Nepstad. 1994. The role of shrubs *Cordia multispicata* Cham. as a succession facilitator in an abandoned pasture, Paragominas, Amazonia. *Vegetatio* 115:91–99.

Warner, Katherine. 1995. *Agriculteurs itinérants: connaissances techniques locales et gestion des ressources naturelles en zone tropicale humide.* FAO, Rome.

Wegner, J. F. and G. Merriam. 1979. Movement by birds and small mammals between a wood and adjoining farm habitats. *Journal of Applied Ecology* 16:349–357.

Whitmore, T. C. 1990. *An Introduction to Tropical Rain Forests.* Oxford University Press, New York.

Yandji, E. 1982. Traditional agro-forestry systems in the Central African Republic. *Agroforestry in the African Humid Tropics,* ed. L. H. MacDonald, pp. 52–55. Tokyo: United Nations University, Tokyo.

Yarranton, G. A. and R. G. Morrison. 1974. Spatial dynamics of a primary succession: nucleation. *Journal of Ecology* 62: 417–428.

APPENDIX 1.—Species of remnant trees found in Ntumu fields at Nkongmeyos. For each species is given the total number of individuals along the edge or in a central position in the field, and their size. "Edge" means the tree's trunk was located on the limit line of the field and central means all others. Large trees are those ≥35 m tall; medium trees are 15–35 m tall; small trees are those <15m tall. Wood-hardness: A = hard; B = mid-hard; C = soft; I = undetermined.

Species (Family)	Wood hard-ness	Tree position in the field		Tree size			Total
		Edge	Central	Large	Medium	Small	
Triplochiton scleroxylon K. Schum. (Sterculiaceae)	C	28	18	40	5	1	46
Terminalia superba Engl. and Diels (Combretaceae)	C	10	21	27	3	1	31
Ceiba pentandra Gaertn. (Bombacaceae)	C	13	12	24	1	—	25
Irvingia gabonensis (Aubry Lecompte ex. O'Rorke) Baill. (Irvingiaceae)	A	12	7	16	3	—	19
Chlorophora excelsa (Welw.) Benth. (Moraceae)	B	5	11	4	10	2	16
Albizia adianthifolia (Schum.) W. F. Wight (Mimosaceae)	C	13	2	8	7	—	15
Musanga cecropioides R. Br. (Moraceae)	C	—	15	4	7	4	15
Pycnanthus angolensis (Welw.) Exell (Myristicaceae)	C	9	6	12	3	—	15
Erythrophleum ivorense A. Chev. (Caesalpiniaceae)	A	10	4	13	1	—	14
Eribroma oblongum (Mast.) Bod. (Sterculiaceae)	B	5	8	12	1	—	13
Pterocarpus soyauxii Taub. (Papilionaceae)	B	6	5	11	—	—	11
Albizia spp. (Mimosaceae)	C	7	3	1	6	3	10
Duboscia macrocarpa Bocq. (Tiliaceae)	A	3	4	4	2	1	7
Xylopia spp. (Annonaceae)	C	6	1	2	4	1	7
Canarium schweinfurthii Engl. (Burseraceae)	C	4	2	5	1	—	6
Myrianthus arboreus P. Beauv. (Moraceae)	B	3	2	3	2	—	5
Tricoscypha abut Engl. (Anacardiaceae)	C	3	2	4	—	1	8
Anthocleista schweinfurthii Gilg. (Loganiaceae)	C	2	2	—	4	—	4
Bridelia micrantha (Hochst.) Baill. (Euphorbiaceae)	C	1	3	2	2	—	4
Cordia platythyrsa Bak. (Boraginaceae)	C	2	2	2	—	2	4
Ficus spp. (Moraceae)	C	3	1	2	2	—	4
Petersianthus macrocarpum (P. Beauv.) Liben (Lecythidaceae)	A	3	1	2	2	—	4
Vitex spp. (Verbenaceae)	C	2	2	—	4	—	4
Desbordesia glaucescens (Engl.) (Irvingiaceae)	A	—	3	3	—	—	3
Enantia chlorantha Oliver (Annonaceae)	C	2	1	2	1	—	3
Zanthoxylum macrophyllum L. (Rutaceae)	C	—	3	3	—	—	3
Ficus vogelii (Micq.) Miq. (Moraceae)	C	1	2	2	1	—	3

APPENDIX 1.—(continued)

Species (Family)	Wood hardness	Tree position in the field		Tree size			Total
		Edge	Central	Large	Medium	Small	
Klainedoxa gabonensis Pierre (Irvingiaceae)	A	—	3	1	2	—	3
Pentaclethra macrophylla Benth. (Mimosaceae)	C	3	—	2	1	—	3
Phyllanthus spp. (Euphorbiaceae)	C	1	2	3	—	—	3
Barteria fistulosa Mast. (Passifloraceae)	C	—	2	—	2	—	2
Canthium spp. (Rubiaceae)	C	2	—	1	1	—	2
Croton oligandrus Pierre (Euphorbiaceae)	C	1	1	—	2	—	2
Ficus natalensis Hochst. (Moraceae)	C	1	1	—	2	—	2
Grewia spp. (Tiliaceae)	C	2	—	—	2	—	2
Lonchocarpus sericeus (Poir.) H. B. and K. (Mimosaceae)	C	2	—	—	2	—	2
Lophira alata Banks ex. Gaertn. (Ochnaceae)	A	1	1	2	—	—	2
Macaranga hurifolia Beille (Euphorbiaceae)	C	1	1	—	2	—	2
Macaranga spp. (Euphorbiaceae)	C	1	1	—	1	1	2
Margaritaria discoidea (Baill.) Webster (Euphorbiaceae)	A	2	—	—	2	—	2
Antrocaryon klaineanum Pierre (Anacardiaceae)	C	—	1	—	—	1	1
Berlinia spp. (Caesalpiniaceae)	B	1	—	1	—	—	1
Caesalpiniaceae undetermined species	I	1	—	—	1	—	1
Dacryodes edulis (G. Don) Lam. (Burseraceae)	B	—	1	1	—	—	1
Dacryodes macrophylla (Oliv.) Lam. (Burseraceae)	B	—	1	1	—	—	1
Desplatsia sp. (Tiliaceae)	I	1	—	—	1	—	1
Entandrophragma utile (Dave and Sprague) Sprague (Meliaceae)	B	—	1	—	—	1	1
Eriocoelon macrocarpum Gilg. (Sapindaceae)	I	1	—	—	1	—	1
Ficus sur Forssk. (Moraceae)	C	—	1	1	—	—	1
Funtumia elastica (Preuss.) Stapf (Apocynaceae)	C	1	—	1	—	—	1
Grewia brevis (Spreng.) Monachino (Tiliaceae)	C	1	—	—	1	—	1
Hallea stipulosa (DC.) O. Ktze. (Rubiaceae)	C	1	—	—	1	—	1
Irvingiaceae undetermined species	I	1	—	—	1	—	1
Khaya ivorensis A. Chev. (Meliaceae)	C	—	1	1	—	—	1
Lovoa trichilioides Harms (Meliaceae)	C	—	1	1	—	—	1
Mimosaceae undetermined species	I	—	1	—	1	—	1
Monodora sp. (Annonaceae)	I	—	1	1	—	—	1

APPENDIX 1.—(continued)

Species (Family)	Wood hardness	Tree position in the field		Tree size			Total
		Edge	Central	Large	Medium	Small	
Nauclea sp. (Rubiaceae)	B	1	—	1	—	—	1
Persea americana Mill. (Lauraceae)	C	—	1	1	—	—	1
Rauwolfia macrophylla Stapf. (Apocynaceae)	C	1	—	—	1	—	1
Ricinodendron heudelotii Müll. (Euphorbiaceae)	C	—	1	1	—	—	1
Sapindaceae undetermined species	I	1	—	1	—	—	1
Spathodea campanulata P. B. (Bignoniaceae)	C	1	—	—	—	1	1
Tetrapleura tetraptera (Schum. and Thonn.) Taub. (Mimosaceae)	C	1	—	1	—	—	1
Tetrorchidium dimosthemum (Euphorbiaceae)	C	1	—	—	1	—	1
Tetrorchidium sp. (Euphorbiaceae)	C	1	—	—	1	—	1
Xylopia quintasii Auct. (Annonaceae)	C	—	1	1	—	—	1
Total		188	167	231	102	22	355

The Cambridge World History of Food. Kenneth F. Kiple and Kriemhild Coneè Ornelas (eds.). Cambridge University Press, Cambridge. 2000. 2 vols. Pp., vol. 1, xlii, 1–1120; vol. 2, xii, 1121–2153. Illus., scientific name list, indices. $175.00 (two-volume set, cloth). ISBN: 0-521-40214-X (vol. 1), 0-521-40215-8 (vol. 2), 0-521-40216-6 (set).

This monumental achievement provides an indispensable reference for anyone interested in food and foodstuffs. Readers of this journal will be interested in the whole work, but particularly in the first parts, dealing with food prehistory and ethnobiology.

Subsequent parts deal with nutrition, malnutrition, and food history. These I will not review, except to say that they are uniformly competent and interesting, and provide up-to-date references. Chapters on China (Françoise Sabban), Japan (Naomichi Ishige), South America (Donald Gade), and southern Europe (Kenneth Albala), as well as the whole section VI, "History, Nutrition, and Health," are notably interesting to ethnobiologists. One warning: the chapters on iron (Susan Kent and P. Stuart-Macadam) and iron deficiency (Susan Kent), as well as Leon Abrams' chapter on vegetarianism, are controversial and readers should compare them with more orthodox literature on the subject.

The section on food prehistory includes excellent chapters on methods and data analysis, and a chapter by Mark Cohen presents his hypotheses on the process of domestication. I personally find his ideas intriguing, but not convincing, and would rather have seen a more general review of views on domestication. Fortunately, such a review is provided in the chapters by Joy McCorriston on barley and wheat, and these seem considerably more convincing than Cohen's.

The much longer section on ethnobiology provides accounts of foods, from amaranth to wine. The selection of foods included seems somewhat strange: bison, muscovy ducks, and khat are included, but apples, pears, and pigeon peas are not. Chapters are generally excellent but are uneven in quality and coverage. McCorriston's superb chapters (noted above) deal almost exclusively with domestication in prehistory. Many other chapters (e.g., sugar, by J. H. Galloway) deal primarily with recorded history. Still others (e.g., soybeans, by Thomas Sorosiak) are best on modern uses and processing.

Some chapters are sorely in need of updating. J. M. J. de Wet, a leading expert on African millets, has missed important recent findings on Chinese millets. The chapter on cruciferous and green leafy vegetables by Robert Field ignores modern work on the cabbage family, even the readily accessible and excellent systematization of taxonomy in Smartt and Simmonds (1995:62–88).

My favorite chapters are those on maize and white potatoes by Ellen Messer. She provides detailed reviews that cover everything from prehistory to modern processing and consumption patterns. Her chapters are exemplary in their selection of coverage, balance of data and analysis, and judicial interpretation. Closely following these are chapters by Daniel Gade, who covers most of the major domestic animals, as well as South American foods. He is both a top scholar and an excellent writer. Many other excellent chapters might be noted, including taro

(Nancy Pollack) and tomatoes (Janet Long). Sheldon Aaronson's chapter on fungi gives a monumental list of all the major fungi eaten in the world.

Some chapters are notably weak. Hansjörg Küster tries to cover "Spices and Flavorings" in seven pages. His bibliography has only five items, four of them secondary sources. The chapter is based on the long-discredited idea that spices were used to mask the flavor of spoiled food. Quite apart from the economic absurdity of this (spices, worth their weight in gold, used to save a few cents on meat?), it would explain, if it were true, only the medieval European usage. But his argument neither holds here, for medieval European elites insisted on fresh meat, and would have been disgusted by our "aged" beef. Certainly, no one affluent enough to buy spices in the heavy spice-using regions of the world (Indonesia, Mexico, etc.) eats, or has to eat, spoiled food. More importantly, every cook knows that spices *bring out* the taste of foods. I have been the unlucky guinea pig in some trials of spices as concealers of spoiled food taste, and—trust me, dear reader—don't try it. The same author's chapter on rye, while at least accurate, is only three pages long, out of date, and confined largely to northern Europe in coverage. In fairness, his chapter on the history of North European food is very fine.

On the whole, readers can be safely directed to this book for up-to-date reviews of the literature, but readers must beware, especially of the shorter and less heavily referenced chapters. Sadly, in spite of the price of the book, it is too uneven and unreliable to serve as one's sole reference and must be used in conjunction with other standard sources. This said, the set provides so much that is hard to find elsewhere, and so many unique and up-to-date reviews, that it will remain a basic reference for some time to come.

E. N. Anderson
Dept. of Anthropology
University of California
Riverside, CA 92521-0418

REFERENCE CITED

Smartt, J. and N.W. Simmonds. 1995. *Evolution of Crop Plants.* Longman Scientific and Technical, New York.

Ethnobiology at the Millennium: Past Promise and Future Prospects. Richard I. Ford (ed.). Anthropological Papers no. 91. Museum of Anthropology, University of Michigan. Museum of Anthropology Publications, Ann Arbor. 2001. $20.00 (paper). ISBN: 0-915703-50-5.

The papers in this volume are a result of the Presidents' Symposium at the annual meeting of the Society of Ethnobiology in Ann Arbor, Michigan, March 2000. All authors are former presidents of the society, with one exception: a former editor of the *Journal of Ethnobiology.* Similar in scope to Richard Ford's edited volume, *The Nature and Status of Ethnobotany* (Ford 1994), this book assesses where

ethnobiology has gone and where it is going. This is done in each president's semi-autobiographical and historical analysis of trends in ethnobiology.

Ford introduces the presidents' papers with "Ethnobiology at a Crossroads," a paper that covers the historical foundations and current trends in the field. The author reviews the table of contents of past journal issues to compile a table showing the trends in the field by sub-discipline. Not surprisingly, ethnobotany, ethnopharmacology, and paleoethnobotany lead the field with the most articles published in the journal. Zooarchaeology and folk classification are close behind, with conservation and ethnoecology drawing more attention in recent years. Unfortunately, ethnoentomology is not on the authors' lists. I consulted the index of the *Journal of Ethnobiology* (Thomas 2000) and found several articles on the subject, mostly the work of Posey (1981, 1983, 1986) in Brazil and that of Ramos-Elorduy de Conconi et al. (1984, 1988) in Mexico and an article on hallucinogenic ant consumption in south-central California (Groark 1996). Furthermore, chemical-ecological theories, having foundations in entomology, are being applied to human-plant interactions (Johns 1990) and should qualify as important components of the greater ethnobiological discourse. Ford goes on to discuss recent trends in ethnobiology, molecular archaeology, conservation biology, applied ethnobiology, environmental education and consultations in native legal cases.

The next four chapters discuss the importance of ethnobiology in answering questions about the human past. Elizabeth S. Wing covers the "Potentials of Zooarchaeology for Better Understanding of the Human Past" in a paper that discusses the history of the discipline and its possible roles in the future. Two papers, from Steven A. Weber and Karen R. Adams, are archaeobotanical case studies from South Asia and the southwestern U.S., respectively. This section closes with Paul Minnis rebutting the common perception that paleoethnobotany is irrelevant in "One Possible Future of Paleoethnobotany."

The second half of the book begins with a paper from Eugene S. Hunn, "An Ethnozoological Perspective on the Ethnobiological Enterprise." In this analysis the author covers the paradoxical case of ethnobotany drawing more attention than ethnozoology. Hunn analyzes the case with a familiar argument (see Hunn 1982) based on perceptual versus utilitarian perspectives. Cecil Brown follows with a case study of Amerindian nomenclature for "oak" and the relevance of linguistic ethnobiology. Catherine S. Fowler contributes a paper concerning ethnobiological methods, particularly as they apply to ethnography and linguistics. Nancy Turner delivers perhaps the most self-reflexive paper about ethnobotany in British Columbia and the role of the Society of Ethnobiology members in her career. This sets up the closing paper by Eugene N. Anderson who reviews the previous papers, adds his own autobiographical notes, and discusses the role of ethnobiology in solving problems related to resource management and conservation.

My main criticisms of this book are twofold. The book is heavy on the paleoethnobotanical and archeobotanical aspects of the discipline. And there seems to be nothing unifying about the papers that follow the chapters on ethnobiology and the human past. While the paper by Hunn is particularly insightful, the papers by Fowler, Brown, Turner, and Anderson are seemingly disparate. In summary, if the papers included in this volume were more balanced and represen-

tative of the various sub-disciplines in ethnobiology, the book would be stronger and of interest to a broader audience. Otherwise, this is a fine edition that examines the current status of ethnobiology and its historical foundations. It would be useful to use at the end of an introduction to ethnobiology graduate course and would work well with Minnis' (2000) recently published edited volume of selected articles from the journal. It is an inexpensive book that should attract readership among both Society members and readers of this journal.

Kevin D. Janni
Department of Botany
University of Hawaii at Manoa
Honolulu, HI 96822

REFERENCES CITED

Ford, Richard I. 1994. *The Nature and Status of Ethnobotany.* Anthropological Papers no. 67. University of Michigan Museum of Anthropology, Ann Arbor.

Groark, Kevin P. 1996. Ritual and therapeutic use of "hallucinogenic" harvester ants (*Pogonomyrex*) in native south-central California. *Journal of Ethnobiology* 16:1–29.

Hunn, Eugene S. The utilitarian factor in folk biological classification. *American Anthropologist* 84:830–847.

Johns, Timothy A. 1990. *The Origins of Human Diet and Medicine.* The University of Arizona Press, Tucson.

Minnis, Paul E. 2000. *Ethnobotany: A Reader.* University of Oklahoma Press, Norman.

Posey, Darrell A. 1981. Wasps, warriors and fearless men: ethnoentomology of the Kayapo Indians of Brazil. *Journal of Ethnobiology* 1:165–174.

———. 1983. Keeping of stingless bees by the Kayapo Indians of Brazil. *Journal of Ethnobiology* 3:63–73.

———. 1986. Topics and issues in ethnoentomology with some suggestions for the development of hypothesis-generation and testing in ethnobiology. *Journal of Ethnobiology* 6: 99–120.

Ramos-Elorduy de Conconi, J., J.M.P. Moreno, C.M. Mayaudon, F.R. Valdez, M.A. Perez, E.E. Prado, and H.B. Rodriguez. 1984. Protein content of some edible insects in Mexico. *Journal of Ethnobiology* 4:61–72.

Ramos-Elorduy de Conconi, J. and M. EN C. J.M.P. Moreno. 1988. The utilization of insects in the empirical medicine of ancient Mexicans. *Journal of Ethnobiology* 8(2):195–202.

Thomas, Michael B. 2000. Index of journal articles presented in the *Journal of Ethnobiology* from 1981–1999. Society of Ethnobiology, Summer 2000.

Introdução à etnoentomologia: Consideraçoes metodológicas e estudo de casos. (Introduction to Ethnoentomology: Methodological Considerations and Case Studies). Eraldo Medeiros Costa Neto. Universidade Estadual de Feira de Santana, Bahia, Brazil. 2000. Pp. 131. ISBN: 85-7395-020-X.

This book is a compilation of short chapters: one of introduction, one of methodology, five that present case studies, and an epilogue. The book is an attempt to assemble and summarize the author's ethnoentomological works, some of which have appeared in the *Journal of Ethnobiology* (e.g., vol. 18(1):1–13; 1998) and other academic journals.

The introductory chapter does an excellent job summarizing the available

ethnoentomological literature, but fails in terms of actually *introducing* the subject with much creativity. What is presented is an abbreviated and superficial laundry list of the ways in which insects intersect with various segments of human society. Much of this list is indeed interesting, but the summation does not leave the reader with any sense of introduction and with no sense of a road map for the chapters that follow.

The title of the book and, specifically, the title of the second section made the reviewer question whether it is necessary to partition the methods of ethnoentomology from the wider context of ethnobiology. Extrapolating, should we demand additional texts on the methodologies specific to "ethnoichthyology," "ethnobryology," or "ethnograminology"? The chapter presents a basic summary explaining the concepts of an interview schedule, emic versus etic approaches to the topic, data collection and the validity of qualitative and quantitative data, and the problems and possibilities inherent within the idea of an omniscient informant. The reader will find little difference between the contents of this chapter and the basic tenets of ethnobotany as described in Martin (1995) or Cotton (1996), both of which are frequently cited. Little effort was made to describe some of the difficulties inherent in species collecting or to describe ways that these difficulties should be addressed in the field. There is certainly value, however, in having this information presented in Portuguese, and the chapter will be useful for students pursuing ethnobiological research.

The strength of the text obviously lies in the case studies, and in his research, Costa Neto is skillful and creative. The first case study presents research detailing the "entomoprojective ambivalence hypothesis"—that is, the projection of feelings of disgust toward non-insect animals by assigning them to insect categories. The hypothesis presents a widely diffuse pattern in various rubrics of human culture, but the description presented is quite interesting and deserves further attention if for no other reason than intrigue.

The second case study—the best of the crop—is traditionally ethnographic and expertly describes the importance of bees in the life of the Pankararé Indians of Bahia, Brazil. The research, based on 30 collected specimens, reveals the presence of several intermediate emic taxa for bees. Most notably among these is the division between aggressive and non-aggressive bees (*abeja braba* and *abeja mansa,* respectively) which is superficially reminiscent of the division between wood densities in many cultures (i.e., hardwoods versus softwoods).

Thirdly, Costa Neto presents an account of the presence of insects in advertisements, an interesting and refreshing departure from much of the more traditional ethnobiological literature. He finds, not surprisingly, that insects are not well represented in advertising and, where they are present, butterflies tend to be used most frequently. His explanation—that humans are insect averse but favor butterflies because of their "cultural importance"—seems logical.

The final two case studies respectively examine the use of insects as medicine among rural and urban communities of northeastern Brazil and the use of insects, more generally, as a source of human food. Both chapters are essentially notes, giving the reader an excellent synopsis of the two subjects.

Overall, the text is certainly a very interesting read. But, where the importance of a text by a Brazilian ethnobiologist written in Portuguese cannot be

denied, the importance of the text for the field of ethnobiology is limited. Yet for those individuals whose focus is specific to understanding the relationship between humans and the insect world, I suspect this text will be thoroughly enjoyed.

Darron A. Collins
World Wildlife Fund
1250 24th St., NW
Washington, DC 20037

REFERENCES CITED

Cotton, C.M. 1996. *Ethnobotany: Principles and Applications.* John Wiley and Sons, Chichester, New York.
Martin, G.J. 1995. *Ethnobotany: A Methods Manual.* Chapman and Hall, London.

On Biocultural Diversity: Linking Language, Knowledge, and the Environment. Luisa Maffi (ed.). Smithsonian Institution Press, Washington D.C. 2001. Pp. 560. $65.00 (cloth); $34.95 (paper). ISBN: 1-56098-905-X.

The origins of this book lie in a conference organized by Luisa Maffi in 1996 at the University of California, Berkeley entitled "Endangered Languages, Endangered Knowledge, Endangered Environments." While the linkages between biological diversity and cultural diversity were well explored prior to this meeting, researchers had, according to Maffi, neglected to include linguistic diversity as part of the "inextricable" link. The success of that meeting is readily apparent in this volume. As editor of *On Biocultural Diversity,* Maffi does a superb job of bringing together a wide range of scholars to address the relationship between language, knowledge, and environment.

The introduction by Maffi does more than simply set the stage for the rest of the book. It provides a detailed argument for the relationship between biological diversity and linguistic diversity and suggests some reasons for it. As she notes in the introduction, the "chapters in this book go a long way in telling us why diversity matters. Together—in a way that no individual scholar could accomplish—the authors begin to assemble the pieces of the giant puzzle that is the diversity of life in its various manifestations and complex interrelationships."

The book is divided into four sections. The first, "Language, Knowledge, and the Environment," presents a variety of papers that make a case for how these three domains interact and how they are interdependent. The explanations for why biological diversity and linguistic diversity are connected are not always as complete as they could be. However, there are many fine papers in this section by ethnobiologists and other researchers that present theoretical innovations and compelling reasons for future study.

The second section, "Biocultural Diversity, Persistence, and Loss," builds on much of the theory developed in the first section. As one might expect, most papers deal more with the question of loss than persistence. Whereas clear evidence is provided for language loss and biodiversity loss, the concomittant loss of ethnobiological knowledge loss is left implicit. This apparent omission may be

explained in part by the difficulties inherent in measuring knowledge lost over time. This suggests important goals of future research: developing a methodology to determine rates of knowledge loss (and its persistence), and then setting priorities for studying the most endangered knowledge systems.

The third section, "Perpetuating the World's Biocultural Diversity: Agenda for Action," provides a method of applying the research presented in the earlier sections. This section does not present just a simple view of indigenous and traditional peoples' interactions with their biophysical environment, but also challenges popular notions and reveals the complexity involved in understanding these issues.

The final section, "A Vision for the Future and a Plea," provides some glimmer of hope for an otherwise gloomy situation. Richard Norgaard notes that, despite the language losses that have occurred, we may be entering a period of reculturalization. This is a seeming paradox whereby global processes are leading to greater concentrations of power beyond the nation state, while ethnic and regional expressions lead to greater autonomy. If Norgaard and others (e.g., Ronald Cohen) are right, the dire situation documented in this volume could improve. The inclusion of the code of ethics of the International Society of Ethnobiology as an appendix complements this final section through its encouragement that researchers become active participants in promoting the well being of indigenous and traditional peoples.

Researchers such as Darrell Posey and Michael Warren (to whom the volume is dedicated) stressed the importance of people and culture in the conservation equation. Much of the research presented in this volume will also help solve this complex problem. The premise that cultural diversity can not be separated from biological diversity is convincingly argued by some of the top researchers in the world. Contributions from ethnobiologists are many, representing well over half of the volume. As in most edited volumes, there are a few papers that do not fit as well as they could. Overall, however, the volume makes an important contribution to our understanding of biocultural diversity and will certainly be well read and frequently cited in years to come.

John R. Stepp
Department of Anthropology
University of Florida
Gainesville, FL 32611-7305

First Fish, First People: Salmon Tales of the North Pacific Rim. Judith Roche and Meg McHutchison (eds.). University of Washington Press, Seattle. 1998. Pp. 199. Map, photos, illustrations. $24.95 (paper). ISBN: 0-295-97739-6.

Among all of the organisms that provide the basis for human subsistence, few have loomed as large within particular aboriginal societies as the salmon of the north Pacific Rim. The indigenous peoples who depended on salmon and their yearly return rightly held these fish in awe. Salmon were a staple food source and played a key role in deeply held beliefs, rituals, and oral traditions. Today,

despite dramatic changes in these societies and in the fish populations on which they have depended, the intimate relationship between humans and salmon persists. Roche and McHutchison's *First Fish, First People,* an illuminating collection of writings by indigenous authors from around the north Pacific, gives a glimpse of the many past and present roles that salmon have played in these societies.

The distinctive tone of this book can be attributed to the unique voice of each author. All are talented indigenous writers, representing myriad nations: the Ainu of Japan, the Ulchi and Nyvkh of eastern Siberia, the Tlingit of Alaska, the Okanagan and Coast Salish of western Canada, the Makah, Spokane, Coeur d'Alene, and many other tribes of the American Northwest. As the salmon unified their ancestors' cultures, so the topic of salmon is what unifies this eclectic collection of ethnographic essays, historical recollections, poems and stories.

By and large, the authors include some of the most prominent and educated representatives of their respective societies. They include such notable indigenous intellectuals as award-winning author and filmmaker, Sherman Alexie, who helped identify and bring together authors for this unique project. The collection begins with two haunting prose poems by Alexie, "The Powow at the End of the World" and "That Place Where Ghosts of Salmon Jump." Alexie's words express an abiding sadness and anger provoked by the transformation of the Spokane River, which runs through his homeland. As in many rivers of this region, dam construction obliterated salmon runs, eliminating the fish from the territories of many tribes.

Following Alexie's lead, each of the book's chapters juxtaposes past upon present images in order to convey the traditional roles of the salmon and the implications of their loss. Shigeru Kayano and Shiro Kayano provide illuminating overviews of the role of salmon in Ainu culture—they present many facets of this relationship from traditional songs of salmon, to the production of salmon-skin shoes, to the draconian Japanese prohibitions on subsistence salmon fishing in the twentieth century. Next, Gloria Bird provides a detailed, first person narrative from the perspective of a woman assisting in the traditional fishery on the interior Columbia River. A vivid poem by Miekko Chikappu follows, evocatively combining imagery of the returning salmon with bits of Ainu lore. Elizabeth Woody juxtaposes her insightful discussion of the transformation of Celilo Falls—a tremendously important multi-tribal fishing site of the Columbia River, now drowned behind dams—with a compelling semi-fictional tale of contemporary people from this region. Nadyezhda Duvan provides a welcome glimpse of the elaborate myths and rituals surrounding the salmon and its annual return to Ulchi territory. Nora Marks Dauenhauer provides a rich mixture of Tlingit poems and reminiscences from childhood fishing camps in Alaska. In spare but vivid words, Ito Oda explicates the role of Ainu ritual and worldview in shaping salmon harvesting practices. Sandra Osawa provides a historical overview of 150 years of inequitable competition over the dwindling salmon runs in the American Northwest that has placed Native fishermen at odds with White interests. Vladimir Sangi tells a Nyvkh tale of human encounters with salmon, providing a rare view into the lives and practices of these people of the Russian Far East. With a tone reminiscent of magical realist prose, Lee Maracle alternates between mythic imagery and descriptions of aboriginal struggles to maintain their fishing rights. In

the book's final chapter, Jeanette Armstrong recounts the many impositions that industrialized societies place on the aboriginal relationship with salmon, degrading the health of indigenous societies and salmon runs alike.

This diverse collection of essays leaves the reader with impressions, glimpses of the relationship between people and salmon, rather than a singular, definitive narrative. The value of the North American contributions in particular tends to be artistic rather than ethnographic, though many of these chapters are rich in historic detail. The Japanese and Russian accounts, elusive within English language literatures, are generally richer in ethnographic content. The volume's foremost strengths and its greatest weaknesses emanate from the distinctive characteristics of its authors. As educated spokespeople of their respective societies, most are gifted, expressive authors. However, as members of a germinal aboriginal intelligentsia, many live under circumstances quite distinct from the experiences of many aboriginal peoples in this region. As Nora Marks Dauenhauer (p. 116) writes in her poem "How to Make Good Baked Salmon from the River,"

> [Salmon]'s best made in dryfish camp
> on a beach by a fish stream
> on sticks over an open fire,
> or during fishing
> or during cannery season
> In this case we'll make it in the city,
> baked in an electric oven on a black fry pan.

The book provides accounts of peoples in rapid transition from the perspective of some who are at the forefront of change. While this observation may raise questions of "representativeness," it should not be interpreted as a criticism. On the contrary, the personal longings for lost salmon, as presented in *First Fish,* raises fundamental questions and may portend the future symbolic role of salmon within these societies. The volume stands as a unique, informative, and highly readable account of the relationship between people and salmon around the north Pacific Rim. It reveals remarkable parallels, not only in the pre-colonial significance of salmon, but also in the twentieth-century transformation of lands and cultures in the wake of modernization, tribal displacement, and the consolidation of national territories. It demonstrates that, almost uniformly around the north Pacific Rim, aboriginal access to salmon has been restricted and traditional ties to these fish have been under persistent threat. All too often, the results have proven devastating. It is a telling account, sometimes humorous, sometimes haunting, and consistently entertaining. For anyone with interests in the indigenous peoples and salmon of the north Pacific it is well worth the read.

Douglas Deur
Department of Geography
University of Nevada–Reno
Reno, NV 89557-0042

Journal of Ethnobiology 22(1): 173–177 Summer 2002

GUIDELINES FOR AUTHORS

The *Journal of Ethnobiology* invites manuscripts based on original research in any area of ethnobiology, the interdisciplinary study of the relationships of living things with human cultures worldwide. Topics include but are not limited to paleoethnobotany, zooarchaeology, ethnobotany, ethnozoology, ethnoecology, linguistic ethnobiology, and other related areas in anthropology and biology.

THE REVIEW PROCESS

The *Journal of Ethnobiology* is peer-reviewed. Upon receipt of a manuscript, the Editor will send it out for review. When the reviews are received, the Editor will decide the status of the manuscript: acceptable (acceptance contingent on any necessary minor revision and corrections, proper formatting, publication quality illustrations, and completeness); revise and resubmit (reconsideration contingent on more substantial additions, re-writing, or re-organization); reject; not suitable for this journal. After the Editor's decision and reviews are transmitted to the author, most positively reviewed manuscripts will go through several more rounds. Final decisions concerning publication are made by the Editor.

SUBMITTING THE MANUSCRIPT TO THE JOURNAL

Send three double-spaced copies of your manuscript to the Editor. A manuscript should include title page, three abstracts (English; Spanish or Portuguese; French); the text itself; references cited; any tables (numbered in the order they are called for in the text); any figure captions (numbered in the order they are called for in the text); and the figures (figure numbers on back, with orientation indicated). The text pages should be numbered and be double-spaced throughout (including abstracts, text, notes, references cited, and figure captions). Note that initially illustrations should be sent as high-quality photocopies or print-outs. Send diskettes and original art or photographs only after consultation with the Editor.

CONTENT, STYLE, AND FORMAT

Consult the Editor and the *Chicago Manual of Style* for matters not dealt with in these guidelines.

Title Page.—The title page is primarily for the convenience of the editorial staff. It should include (in order): title, date submitted, the word count of the body of the text, the word count of the "references cited," the number of tables, and the number of figures. Towards the bottom of the page put author's name(s), mailing/e-mail addresses, phone for at least one author, as well as any temporary addresses (e.g., summer address, field address, applicable dates). The title and name,

affiliation, and address of each author are to be repeated on the first page of the actual manuscript as you would like them to appear in the journal.

The Beginning.—Center, double-spaced and in example style as follows:

TITLE

AUTHOR 1[a] and AUTHOR 2[b]

[a]*Address*
(e-mail optional)
[b]*Address*
(e-mail optional)

If authors are at same institution, there is no need to repeat the mailing address.

Abstract.—With rare exceptions, each manuscript must include an informative one-paragraph abstract which briefly (fewer than 200 words) summarizes your article. The English abstract begins right after the flush-left heading "ABSTRACT.— " and is followed by five key words that characterize the content of your manuscript for indexing purposes. Abstracts in Spanish (RESUMEN—) or Portuguese (RESUMO.—), and French (RÉSUMÉ.—) follow.

Headings.—For first-order headings, skip two lines. First-order headings are centered, upper case. For text following a first-order heading skip a line and indent. For second-order headings, skip one line; they are flush-left, italics, initial letters of key words capitalized, and followed by a period and a long dash (em-dash), as in this paragraph.

Third-order headings. If a third-order heading is necessary, indent as a new paragraph, use Roman letters, capitalize only first letter (and proper nouns), and end with a period, as in this paragraph.

Scientific Names and Voucher Specimens.—Scientific names (Latin binomials) should be cited in the style of the relevant biological discipline. If you are unfamiliar with that style, consult an appropriate authority. Genus and species must be italicized or underlined in the manuscript; authorities of plants should be cited the first time each is mentioned in the text or in tabular form (example: *Zea mays* L.). The locations where voucher specimens have been deposited for curation should be put in an endnote. The rationale for these requirements has been discussed by Bye (1986), Hunn (1992), Kuhnlein (1986), and Rea (1986).

Vernacular and Indigenous Language Terminology.—For languages that are not written with the Latin alphabet, vernacular or indigenous terminology used as data should be transliterated with a consistent phonemic orthography or practical alphabet. A brief characterization of the orthographic conventions used should be given in an endnote at the first occurrence in the text. To increase readability, indigenous terms should be indicated by ***boldface italics*** to contrast with normal

use of italics for foreign terms and Latin binomials. Terms that are in a language that is commonly written according to well established orthographic conventions (e.g., English, Spanish) should be simply italicized as foreign words.

Authors' Responsibilities to Others.—Authors are responsible for obtaining all necessary permissions to reproduce images and other copyrighted material. Credit or source information for images should be provided in figure captions.

Miscellaneous Items.—You may indicate words to be italicized in your manuscript with italics or underlining, but be consistent.

Use metric units for all measurements (for example, cm, ha, kg). English units may be added in parentheses, spelled out. Exception: the original research cited used English measurements.

References to figures and tables in the text should appear as: (Figure x, Table y). Figure captions follow the style:

FIGURE 1.—Your caption.

TABLE 1.—Your heading.

Citations.—The journal discourages the use of endnotes except for source references to unpublished information (e.g., personal communications, voucher specimen information and location). In-text citations should be in social science style. If an item has three or more authors, cite only the first author individually: Hole et al. (1969) or (Hole et al. 1969). If more than one paper is cited, put in alphabetical order, not date of publication: (Balée 1986; Posey 1984, 1986). If chronology is important, you can write, for example: "as Posey (1984) and Balée (1986) have pointed out. . . ."

Unpublished Sources.—We discourage the use of unpublished sources. It is difficult, often impossible, for the reader to verify or check the interpretation of material cited in this way. If it is absolutely necessary to use an unpublished source, provide additional information as a note: the name and affiliation of the person or institution that is the source of the information. Do not put this information in the section REFERENCES CITED.

Notes.—Footnotes at the bottom of the page are not permitted. Endnotes should be avoided. If they are necessary (especially for unpublished sources), they should appear at the end of the text, marked by a first-order heading, NOTES, before the REFERENCES CITED section.

Acknowledgments.—If you would like to include ACKNOWLEDGMENTS, place them after any NOTES and before the REFERENCES CITED section.

Appendices.—Appendices should be used sparingly; if the information is important enough to include in your article, you try to incorporate it in your text or in text tables. Place appendices just before the REFERENCES CITED section. Appendices should be numbered and follow the style:

APPENDIX 1.—Title.

References Cited.—Works referred to in your text should be listed in a separate section under the first-order (centered, upper case) heading, REFERENCES CITED. In general, the names of authors of cited works should be given as they were

in the original publication. If the author's publications use different styles (see below, 1984 work by Karen R. Adams, 1988 work by Karen Rogers Adams), choose one consistently. Keywords (nouns, adjectives, and verbs) should be upper case for English language book, journal, and series titles. Book and journal titles are italicized. Do not use abbreviations for journal titles. Do not list works which are not cited in the text of the manuscript. Examples follow:

Adams, Karen R. 1984. Evidence of wood-dwelling termites in archaeological sites in the southwestern United States. *Journal of Ethnobiology* 4:29–43.

———. 1988. The Ethnobotany and Phenology of Plants in and Adjacent to Two Riparian Habitats in Southeastern Arizona. Ph.D. Dissertation (Ecology and Evolutionary Biology), University of Arizona, Tucson.

Anderson, Edgar. 1956. Man as a maker of new plants and new plant communities. In *Man's Role in Changing the Face of the Earth,* ed. William L. Thomas, Jr., pp. 763–777. University of Chicago Press, Chicago.

Gleick, Peter H. 2000. Water: the potential consequences of climate variability and change for the water resources of the United States [Online]. Available at http://www.gcrio.org/NationalAssessment/water/water.pdf (verified 13 November 2001).

Harlan, Jack R. and J.M.J. DeWet. 1965. Some thoughts about weeds. *Economic Botany* 19: 16–24.

Hastorf, Christine A. and Virginia S. Popper, eds. 1989. *Current Paleoethnobotany: Analytical Methods and Cultural Interpretation of Archaeological Remains.* University of Chicago Press, Chicago.

Ortega, Martha M. 1972. Estudio de las algas comestibles del Valle de México. *Revista latinoamerica de microbiología* 14:85–97.

Sledge, W. Arthur and Richard Evans Schultes. 1988. Richard Spruce: a multi-talented botanist. *Journal of Ethnobiology* 8:7–12.

List of Tables and Figure Captions.—On a separate page at the end of the manuscript, include a list of tables and figure captions. Credit or source information for tables may appear as a note to the table. Credit or source information for images should be provided in the figure captions.

PREPARING A MANUSCRIPT FOR PUBLICATION

After your manuscript is accepted and requires no more than minor copy-editing, the Editor will ask for a diskette and one hard copy. The electronic version and hard copy must be identical. The text should be double-spaced throughout (including abstracts, text, references cited, legends, and notes), with jagged right margin. Hard copy should be on 8.5 × 11 inch or A4 paper, with at least a 1 inch (2.5 cm) margin on all sides. Do not use the automatic formatting capability of your computer; please send manuscripts in "normal" format only. Note that you should set tabs rather than use the space bar for aligning text.

Camera-ready copies of illustrations (see below) should be submitted with the final manuscript. If you also send electronic versions, black-and-white illustrations must be in TIFF, EPS or PDF format; scan photographs at 300 dpi and line art at 1200 dpi. The author(s) will bear the cost of any required editing (that is, if they cannot do it themselves). The Press also requires that all electronic figure files be submitted with identical hard copy.

Tables.—Tables should be numbered sequentially as they appear in the text. The total page count of tables and figures should be no more than half the number of text pages (that is, fewer than one page of tables or figures for two pages of text). Tables should complement the text. Tabular material should be relevant to the appropriate section of the text, but not repeat it. Tables should be prepared with regular text spaced with tabs, the table function of your word-processing program, or a spreadsheet program, such as Excel. Tables must have brief, self-explanatory titles. Rows and columns of information must be clearly marked and labelled. Use portrait or landscape orientation as needed. Adjust column widths to conserve space without loss of clarity. Each table should be printed on a separate page or pages and placed at the end of the manuscript; each table should also be submitted in a separate electronic file, clearly named. Table heading and information on any one page of a table should be legible on the published page (maximum size of table plus heading: 5 × 7.75 inches). No microprint please, as it is very hard to read. If you cannot comfortably fit the information on a table, perhaps you should rethink its purpose.

Illustrations.—All illustrations, including maps, are figures and should be numbered sequentially as they appear in the text. Illustrations should be submitted at a size which can be published on a page of the journal without further reduction (maximum size of image plus caption: 5 × 7.75 inches). No microprint please, as it is very hard to read. Photographs should be black-and-white glossy prints of good contrast and sharpness with metric scales when appropriate. Each illustration should have the author's name(s) on the back along with the figure number and an arrow indicating the top of the figure. Electronic versions should appear in separate files, clearly labelled. Figure captions, listed after table headings at the end of the manuscript, should include source or credit. It is the responsibility of the author to obtain any necessary permissions.

REFERENCES CITED

Bye, Robert A., Jr. 1986. Voucher specimens in ethnobiological studies and publications. *Journal of Ethnobiology* 6:1–8.

Chicago Manual of Style. 1993. *Chicago Manual of Style,* 14th ed. University of Chicago Press, Chicago. (or most recent edition)

Hunn, Eugene S. 1992. The use of sound recordings as voucher specimens and stimulus materials in ethnozoological research. *Journal of Ethnobiology* 12:187–198.

Kuhnlein, Harriet V. 1986. Food sample collection for nutrient analysis in ethnobiological studies. *Journal of Ethnobiology* 6:19–25.

Rea, Amadeo M. 1986. Verification and reverification. Problems in archaeofaunal studies. *Journal of Ethnobiology* 6: 9–18.